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Cruise Noise of the 2/9th Scale Model of the Large-Scale Advanced Propfan (LAP) Propeller, SR-7A

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LARGE-SCALE ADVANCED PROPFAN (LAP) PROPELLER, SR-7A

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SUMMARY

Noise data on the Large-scale Advanced Propfan (LAP) propeller model SR-7A were taken in the NASA Lewis Research Center 8- by 6- Foot Wind Tunnel. The maximum blade passing tone noise first rises with increasing helical tip Mach number to a peak level, then remains the same or decreases from its peak level when going to higher helical tip Mach numbers. This trend was observed for operation at both constant advance ratio and approximately equal thrust. This noise reduction or, leveling out at high helical tip Mach numbers, points to the use of higher propeller tip speeds as a possible method to limit airplane cabin noise while maintaining high flight speed and efficiency. Projections of the tunnel model data are made to the full scale LAP propeller mounted on the test bed aircraft and compared with predictions. The prediction method is found to be somewhat conservative in that it slightly overpredicts the projected model data at the peak.

E-3746

INTRODUCTION

Advanced turboprop-powered aircraft have the potential for significant fuel savings over equivalent core technology turbofan-powered aircraft. To investigate this potential, NASA has an ongoing Advanced Turboprop Program. One element of this program is the Large-scale Advanced Propfan Program (LAP) (ref. 1) which includes the design, fabrication, and ground tests of a 2.74 m (9.0 ft) diameter propeller. This propeller has been tested statically under the Propfan Test Assessment (PTA) Program (ref. 2), and is being flown on a test bed Gulfstream II aircraft as shown in figure 1. Under the LAP program an aeroelastically scaled model of the propeller, designated SR-7A, has been constructed in 62.2 cm (24.5 in.) size to enable the early determination of the aeroelastic characteristics of the full-scale design and for the measurement of the propeller aerodynamic and acoustic performance over a range of flight conditions in wind tunnel tests. There is concern that the noise from these advanced high speed propellers may be a cabin environment problem for the airplane at cruise.

Preliminary noise measurements of this propeller were made in the NASA Lewis 8- by 6- Foot Wind Tunnel using five transducers embedded in the tunnel

ceiling (ref. 3). A number of other propellers have also been tested in this tunnel (refs. 4 to 7). The preliminary testing of the SR-7A propeller was done at one blade setting angle and at one advance ratio for a number of axial tunnel Mach numbers. The present SR-7A acoustic testing was done using a plate suspended from the tunnel ceiling. The plate contained 12 transducers which enabled a better angular resolution of the acoustic data. More accurate forward arc data was obtainable (ref. 7) on the plate because of a thinner boundary layer.

The testing envelope was expanded from that of the preliminary tests. Three propeller blade setting angles and a number of advance ratios were tested at each tunnel Mach number. This report presents the results of the detailed acoustic measurements taken on the SR-7A propeller and compares the measured noise with a semi-empirical prediction for the design cruise condition.

Apparatus and Procedure

The SR-7A propeller, which is nominally 62.2 cm (24.5 in.) in diameter, was tested for acoustics in the NASA Lewis 8- by 6- Foot Wind Tunnel. Table I shows some of the design characteristics of this propeller. A plan view of the wind tunnel is shown in figure 2(a) and a photograph of the SR-7A propeller in the test section is shown in figure 2(b).

The propeller was tested with three design blade setting angles, measured at the 3/4 radius location of 57.7°, 60.1°, and 63.3°. The 60.1° angle was the design cruise blade setting angle at $M = 0.8$. The preliminary noise report, reference 2, indicated that 57.3° was the design angle but the present aerodynamic testing showed that the 60.1° angle really produced the design conditions. The propeller was operated at these blade setting angles for various advanced ratios and tunnel Mach numbers.

A plate was mounted from the tunnel ceiling, 0.3 propeller diameters from the propeller tip, and transducers were installed flush with the plate surface to measure the noise of the propeller. A photograph of this plate is shown in figure 3(a) and a sketch of the installed plate is shown in figure 3(b). Twelve transducers were installed on the plate centerline which was directly above this propeller centerline. The transducer locations are shown in figure 3(b). The signals from the pressure transducers were recorded on magnetic tape and narrowband spectra were obtained for each of the test points. Typically the narrowband range was 0 to 10 000 Hz with a bandwidth of 32 Hz. However, because the propeller blade passing frequency was so close to the wind tunnel compressor tones at some of the test conditions, some higher resolutions (0 to 2500 Hz with an 8 Hz bandwidth) were performed to isolate the propeller tone.

RESULTS AND DISCUSSION

Noise data were taken for the experimental test conditions listed in table II. The advance ratio (J), the power coefficient (C_p), the helical tip Mach number (M_{ht}), and the percent of measured design thrust are presented in this table. More detailed aerodynamic data is available in reference 8. During these acoustic experiments the thrust balance was not working, therefore

the thrust values presented are taken from aerodynamic tests where identical conditions were available. The thrust is presented as percentages of the measured thrust at the design condition (β = 60.1, M = 0.8, J = 3.06) which was 1161 N (261 lb). As can be seen from table II, thrust data are not available for all of the conditions since the same data points were not performed. In particular no aerodynamic tests were performed at an axial Mach number of 0.65.

The acoustic data is presented in tables III to V.

Peak Blade Passing Tone Variations

It has been indicated in reference 2 that the peak blade passing tone noise first increases with increasing helical tip Mach number and then the noise may decrease from the peak when going to higher helical tip Mach numbers. During this previous testing (ref. 3) all of the acoustic transducers were not operating so some question of that conclusion was possible. The present data allow a more detailed look at this variation of peak tone level with helical tip Mach number.

Variations with helical tip Mach number, constant advance ratio. - The propeller blade setting angle was manually set before each test and the tunnel operated at various axial Mach numbers. Curves of peak blade passing tone noise measured on the plate were plotted versus helical tip Mach number in figure 4. These plots are at constant advance ratio and each tunnel axial Mach number tested yields the helical tip Mach number variation. Data for four advance ratios were obtained.

Figure 4(a) is for an advance ratio, J = 3.5, figure 4(b) for J = 3.25, figure 4(c) for J = 3.06, and figure 4(d) for J = 2.75. Where available, data for all three propeller blade setting angles are shown. As can be seen the data does show a peak tone level at a helical tip Mach number of about 1.15 with the noise leveling off or reducing at helical tip Mach numbers above the peak.

The blade loading increases with blade setting angle. As can be seen from these curves, the noise at subsonic helical tip Mach numbers increases with increasing blade setting angle almost as if the curves were just uniformly shifted higher. This is probably the result of increased loading noise. In the subsonic portion of the curves, the noise increases approximately as the square of the input power ratio.

Figure 4(c) presents the peak blade passing tone variations with helical tip Mach number at the design advance ratio of 3.06. At the highest blade setting angle 63.3°, the noise peaks around a helical tip Mach number of 1.2 and then reduces at the higher helical tip Mach number. The data at the design angle, β = 60.1° and the lower β = 57.7° both show a peak around M_{ht} = 1.15, a reduction around M_{ht} = 1.2 and then a noise increase from the M_{ht} = 1.2 level to the M_{ht} = 1.29 condition. This humped shape to the curve is present for both of these lower loaded blade angles. The hump around M_{ht} = 1.15 may represent a different noise mechanism. Possibilities for this mechanism include "quadruple noise" (ref. 9) and the shock wave pressure rise (ref. 10). As the loading is increased from the 57.7° angle case to the β = 60.1° case the hump is reduced and the hump disappears at the highest loading case

$\beta = 63.3°$. This may indicate that the noise from this mechanism can be seen at the lower loading conditions $\beta = 57.7°$ and 60°, but the loading noise dominates at higher blade angles.

Comparison with previous data (ref. 3). - The previous data, using five ceiling transducers, were taken with a blade setting angle of 57.3° (ref. 3, fig. 5). These data were adjusted to the plate position using 20 log of the distance from the propeller centerline. This resulted in 8 dB being added to the previous data. Figure 5 shows the previous plot of noise versus helical tip Mach number from reference 3 compared with that obtained with a 57.7° blade setting angle. As can be seen in figure 5, the comparison of the peak noise variation with helical tip Mach number for the two sets of data are very good particularly when the difference in angular resolution and the small difference in blade setting angle are considered.

Variations with helical tip Mach number at approximately equal thrust. - The experiments reported herein were performed by testing at fixed advance ratios at different tunnel Mach numbers. Three blade setting angles were tested. Although the tests were not structured to provide this comparison, limited combinations of blade setting angle and advanced ratio can be used to cross plot the data and obtain the variation of peak noise with helical tip Mach number at approximately equal thrust. Figure 6 shows these plots of peak blade passing noise versus helical tip Mach number at approximately equal thrust. Figure 6(a) is for an axial Mach number of 0.85. Here data taken with the 60.1° angle at $J = 3.25$, 63.3° angle at $J = 3.75$ and 57.7° angle at $J = 3.06$ are plotted in this figure. These points are at approximately 50 percent thrust. The thrust at the 57.7° angle at $J = 3.06$ point was not available but at $M = 0.75$ and $M = 0.80$ the thrust were 52 and 50 percent respectively, thus the thrust at $M = 0.85$ was taken to be approximately 50 percent. As observed, the noise reduces at the higher helical tip Mach numbers.

Figure 6(b) is for an axial Mach number of 0.8. Data were again taken from the three blade setting angles with the goal of a curve at approximately 85 percent thrust. Data were available at the 57.7° and 63.3° setting angles at approximately 85 percent thrust but not at 60.1°. Therefore two data points are shown for the 60.1° angle--one at 100 percent thrust and the other at 73 percent thrust. The assumption here being that the 85 percent noise data would lie somewhere in between. As can be seen from this figure, the noise again appears to peak and then level off or reduce from that peak as the helical tip Mach number is increased.

It should be noted here that the reductions from the peak are occurring at the 57.7° case which was somewhat off design. It may be possible to show even more of a noise reduction if a propeller blade were actually designed for this higher helical tip Mach number.

Peak tone contours. - Propeller operating maps showing the curves of power coefficient against advance ratio are shown in figure 7. Attempts have been made to draw contours of constant peak blade passing tone on these operating maps. These curves at $M = 0.9$, 0.8, 0.7, and 0.6, show an overall acoustic "picture" of the effect of blade operating parameters on peak passing tone levels.

These contour plots indicate that changes in propeller tip speed have a larger effect on noise than do changes in blade setting angle. An increase in tip speed at a constant blade setting angle results in tracing a performance curve toward lower advance ratios. Since the noise contours are close to normal to the performance curves, large noise increase are observed. Increases in blade angle at constant tip speed result in going between performance curves at constant advance ratio. Since this movement is close to parallel with the noise contours only a small noise increase occurs.

Directivities

Blade passing tone levels for the SR-7A propeller are shown as a function of angular position in figure 8. Directivities are shown in figure 8 for the design advance ratio ($J = 3.06$) condition at the seven Mach numbers tested.

Each Mach number figure shows the data for the three blade setting angles tested. As can be seen the curves are similar in shape for the different blade setting angles. The peak levels have been shifted with the higher loading (higher blade angle) cases showing more noise. The levels toward the front are closer together than at the peak, particularly at the higher Mach numbers (figs. 8(a) to (d)). This may be an indication that the forward noise may not be controlled by the blade loading.

The directivities at most of the Mach numbers are also similar in shape with the noted exception of the data at $M = 0.7$. Here the directivity is much flatter than at other Mach numbers. The forward noise is higher at $M = 0.7$ than at either $M = 0.65$ or $M = 0.75$ and the noise at the forward most positions around 50° is higher here than at any other Mach number. The helical tip Mach number at $M = 0.7$ is approximately 1.0 so it may be that this is some transient transonic effect. Since the far forward levels are higher here than at any other Mach number, this may represent a cabin noise peak at the far forward angles as the airplance is accelerated to $M = 0.8$ cruise conditions.

Previous directivities at $M = 0.65$ and $M = 0.60$ taken on the tunnel ceiling indicated problems with the data being contaminated with tunnel wall reflections (refs. 3 and 11). The data taken here at 0.3 diameter on the plate rather than on the tunnel wall do not appear to suffer those signal to noise problems.

Airplane Projections

Data adjustments. - The noise measured in the wind tunnel can be projected to flight conditions by using corrections for differences in altitude, size, and distance. The acoustic pressure is assumed to vary inversely with the distance squared and directly with the square of the propeller diameter and the ambient pressure (ref. 9). Correcting a tunnel operating pressure of $76.5\text{x}10^3$n/m2 (11.1 psi) at cruise conditions to a flight altitude of 10.7 km (35 000 ft) yields a decrease of 10 dB.

The acoustic plate is 0.3 diameters from the propeller tip and the airplane fuselage is 0.6 diameters from the tip. Based on the distance from the propeller centerline the size and distance correction yields a decrease of 3 dB. The net reduction from tunnel to flight conditions is then 13 dB.

A plot of the full-scale propeller blade passing tone on the Gulfstream II airplane fuselage at cruise (M_{ht} = 1.14, M = 0.08, β = 60.1°, J = 3.06) is shown in figure 9.

Comparison with prediction. - A graphical method for predicting the noise of the full-scale SR-7 propeller is presented in reference 13. This method is based on theoretical calculation procedures and the computer results have been generalized for the SR-7 propeller. Figures 8, 16, and 22(a) of reference 13 were used to predict the free field SR-7 propeller on the Gulfstream II airplane. Six decibels were added to these free-field numbers to account for the pressure doubling effects of the airplane fuselage.

The prediction method of reference 13 locates its fore and aft positions from the peak overall noise level location. The prediction is placed here on figure 9 by aligning the predicted curve base location with the location of the measured position of maximum overall noise.

As can be seen the prediction compares very well with the projected data. The peak noise level is slightly overpredicted and the level aft of the propeller is slightly overpredicted but in general the comparisons in level and directivity are very good.

The relative levels of the blade passing tone harmonies with respect to the fundamental are also of interest. A comparison of the predicted levels with measured data at the maximum noise position at cruise are shown in figure 10. The predictions for this position are also shown. The measured harmonics relative to the fundamental are mostly lower than predicted with only the fourth harmonic being the same. These comparisons indicated the predictions are somewhat conservative in the sense that they predict higher levels than the noise projected from the model data for both the fundamental blade passing tone and the harmonics at the peak location.

CONCLUDING REMARKS

Noise data on the Large-scale Advanced Propfan proppeller model, SR-7A, were taken in the NASA Lewis 8- by 6- Foot Wind Tunnel. The propeller was tested at three blade angles. Plots of the maximum blade passing tone versus helical tip Mach number at constant advance ratio first rises with increasing Mach number to a peak level then remains the same or reduces from the peak when going to higher helical tip Mach numbers. Some limited curves of maximum blade passing tone versus helical tip Mach number, taken at approximately equal thrust, showed the same reduction from the peak noise level when going to higher helical tip Mach numbers. This noise reduction, or leveling out at high helical tip Mach numbers points to the use of faster rotating propellers as a possible method to limit cabin noise while maintaining high flight speed and efficiency.

Projections for the blade passing noise of the full scale 2.74 m (9 ft) diameter propeller, to be flown on the Gulfstream II test bed aircraft, were made from the wind tunnel model data. These projections were compared with a semi-empirical prediction of the noise. The predicted blade passage tone generally compared very well with the projected data both in level and directivity. The prediction did slightly overestimate the blade passage tone at the

peak and the predicted levels of the harmonics were somewhat higher than the projected data. The prediction method was found to be somewhat conservative in the sense that it overpredicted the projected model data at the peak.

REFERENCES

1. Sagerser, D.A.; and Lundemann, S.G.: Large-Scale Advanced Propfan (LAP) Program Progress Report. AIAA Paper 85-1187, July 1985. (NASA TM-87067).

2. Withers, C., et al: Static Test of the PTA Propulsion System. AIAA Paper 87-1728, June 1987.

3. Dittmar, J.H.: Preliminary Measurement of the Noise From the 2/9 Scale Model of the Large-Scale Advanced Propfan (LAP) Propeller, SR-7A. NASA TM-87116, 1986.

4. Dittmar, J.H.; Jeracki, R.J.; and Blaha, B.J.: Tone Noise of Three Supersonic Helical Tip Speed Propellers in a Wind Tunnel. NASA TM-79167, 1979.

5. Dittmar, J.H.; and Jeracki, R.J.: Additional Noise Data on the SR-3 Propeller. NASA TM-81736, 1981.

6. Dittmar, J.H.; Stefko, G.L.; and Jeracki, R.J.: Noise of the 10-Bladed, 60° Swept SR-5 Propeller in a Wind Tunnel. NASA TM-83054, 1983.

7. Dittmar, J.H.; Burns, R.J.; and Leciejewski, D.J.: An Experimental Investigation of the Effect of Boundary Layer Refraction on the Noise from a High-Speed Propeller. NASA TM-83764, 1984.

8. Stefko, G.L.; Rose, G.E.; and Podboy, G.G.: Wind Tunnel Performance Results of an Aeroelastically-Scaled 2/9 Model of the PTA Flight Test Prop-Fan. AIAA Paper 87-1893, June 1987.

9. Hanson, D.B.; and Fink, M.R.: The Importance of Quadrupole Sources in Prediction of Transonic Tip Speed Propeller Noise. J. Sound Vibr., vol. 62, no. 1, Jan. 8, 1979, pp. 19-38.

10. Dittmar, J.H.; and Rice, E.J.: A Shock Wave Approach to the Noise of Supersonic Propellers. NASA TM-82752, 1981.

11. Dittmar, J.H.: Why Credible Propeller Noise Measurements are Possible in the Acoustically Untreated NASA Lewis 8- by 6-Foot Wind Tunnel. J. Acoust. Soc. Am., vol. 75, no. 6, June 1984, pp. 1913-1914.

12. Dittmar, J.H.: Further Comparison of Wind Tunnel and Airplane Acoustic Data for Advanced Design High Speed Propeller Models. NASA TM-86935, 1985.

13. Parzych, D.; Cohen, S.; and Shenkman, A.: Large-Scale Advanced Propfan (LAP) Performance, Acoustic, and Weight Estimation. (SP-06A83, Hamilton Standard; NASA Contract NASA3-23051) NASA CR-174782, 1985.

TABLE I. - SR-7A PROPELLER DESIGN CHARACTERISTICS

Diameter, cm (in.)	62.2 (24.5)
Number of blades	μ8
Design Mach number	0.80
Design speed, m/sec (ft/sec)	244 (800)
Design advance ratio	3.06
Design power coefficient	1.45
Design power loading, kW/m^2 (hp/ft^2)	257 (32.0)
Integrated design lift coefficient	0.202
Activity factor	227
Design efficiency, percent	79

TABLE II - TEST CONDITIONS

(a) Blade angle equal 57.7°

Axial Mach number	Advance ratio	Helical tip Mach number	Power coefficient	Percent of measured thrust at design[a]
0.9	3.06	1.289	0.177	(b)
.85	3.25	1.182	.045	(b)
.85	3.06	1.218	.360	(b)
.8	3.50	1.076	0	[c]-11
	3.25	1.110	.408	23
	3.06	1.144	.677	50
	2.83	1.193	.961	86
.75	3.5	1.003	0	[c]0
	3.25	1.042	.495	28
	3.06	1.074	.764	52
	2.75	1.137	1.168	105
.7	3.5	.939	.159	8
	3.25	.973	.581	33
	3.06	1.002	.860	52
	2.75	1.061	1.242	98
.65	3.5	.873	.318	(b)
	3.25	.902	.707	
	3.06	.927	.983	
	2.75	.987	1.401	
.6	3.5	.804	.341	9
	3.25	.832	.734	28
	3.06	.858	0.992	43
	2.75	.910	1.149	80

[a]Taken from previous aerodynamic data.
[b]Not available.
[c]Windmill.

TABLE II - Continued.

(b) Blade Angle Equal 60.1°

Axial Mach number	Advance ratio	Helical tip Mach number	Power coefficient	Percent of measured thrust at design[a]
0.9	3.72	1.176	0	[c]-11
↓	3.5	1.208	.374	25
↓	3.25	1.250	.783	(b)
↓	3.06	1.288	1.0046	(b)
.85	3.75	1.108	.248	-4
↓	3.5	1.140	.669	30
↓	3.25	1.181	1.018	54
↓	3.06	1.216	1.268	89
.8	4.1	1.010	0	[c]-9
↓	3.75	1.044	.603	14
↓	3.5	1.074	.947	45
↓	3.25	1.111	1.300	74
↓	3.06	1.148	1.533	[d]100
↓	2.82	1.199	1.786	143
.75	3.75	.978	.606	16
↓	3.5	1.007	.985	42
↓	3.25	1.042	1.315	69
↓	3.06	1.074	1.566	91
↓	2.75	1.137	1.933	147
.7	3.75	.913	.650	21
↓	3.5	.940	1.047	46
↓	3.25	.972	1.390	72
↓	3.06	1.001	1.636	95
↓	2.75	1.062	1.984	145
.65	3.75	.848	.6954	(b)
↓	3.5	.870	1.077	↓
↓	3.25	.901	1.408	↓
↓	3.06	.930	1.673	↓
↓	2.75	.982	2.051	↓
.6	3.75	.782	.729	20
↓	3.5	.807	1.109	40
↓	3.25	.834	1.442	60
↓	3.06	.859	1.693	78
↓	2.75	.908	2.079	118

[a]Taken from previous aerodynamic data
[b]Not available
[c]Windmill
[d]Design condition, by definition this is 100 percent thrust

TABLE II - Concluded.

(c) Blade Angle Equal 63.3°

Axial Mach number	Advance ratio	Helical tip Mach number	Power coefficient	Percent of measured thrust at design[a]
0.9	4.25	1.117	0.1883	2
	4.0	1.143	.614	18
	3.75	1.173	.998	42
	3.5	1.204	1.385	70
	3.25	1.255	1.626	98
↓	3.06	1.289	1.804	124
.85	4.25	1.054	.599	12
	4.0	1.083	.944	34
	3.75	1.110	1.319	53
	3.5	1.140	1.676	94
	3.25	1.184	1.973	108
↓	3.06	1.216	2.157	143
.8	4.25	.994	.906	22
	4.0	1.015	1.301	34
	3.75	1.040	1.626	57
	3.5	1.071	1.915	86
	3.25	1.106	2.217	118
↓	3.06	1.142	2.421	147
.75	4.25	.931	.8542	22
	4.0	.955	1.277	34
	3.75	.976	1.593	57
	3.5	1.003	1.938	81
	3.25	1.041	2.222	111
↓	3.06	1.072	2.433	141
.7	4.25	.870	.889	22
	4.0	.890	1.289	32
	3.75	.912	1.638	53
	3.5	.940	1.965	74
	3.25	.972	2.296	101
↓	3.06	.999	2.504	130
.65	4.25	.805	.932	(b)
	4.0	.823	1.312	
	3.75	.849	1.664	
	3.5	.872	1.986	
	3.25	.903	2.287	
↓	3.06	.931	2.525	↓
.6	4.25	.746	.969	14
	4.0	.764	1.345	34
	3.75	.784	1.677	44
	3.5	.806	2.000	61
	3.25	.833	2.320	77
↓	3.06	.858	2.528	101

[a]Taken from previous aerodynamic data
[b]Not available

TABLE III. - NOISE DATA AT 57.7° BLADE ANGLE

(a) M = 0.9, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	138.0	146.5	154.0	152.0	156.0	155.0	151.0	150.5	134.0
2	-----	-----	-----	(a)	137.5	146.0	137.5	130.0	134.5	131.0	132.5	140.5
3	-----	-----	-----	-----	129.5	139.0	133.5	134.0	137.0	137.5	139.0	140.0
4	-----	-----	-----	-----	(a)	133.5	133.0	133.0	134.0	140.0	142.0	141.5
5	-----	-----	-----	-----	-----	129.0	128.0	131.0	124.5	140.0	143.0	141.0
6	-----	-----	-----	-----	-----	125.0	123.0	123.5	130.0	133.5	139.0	140.0
7	-----	-----	-----	-----	-----	122.0	122.0	(a)	123.0	127.5	135.5	138.0
8	-----	-----	-----	-----	-----	(a)	(a)	-----	127.0	130.0	126.0	135.0

(b) M = 0.85, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	138.0	145.0	151.0	151.0	150.0	149.0	144.5	144.5	136.5
2	-----	-----	-----	(a)	(a)	140.5	140.0	147.0	150.0	148.5	146.5	138.5
3	-----	-----	-----	-----	-----	133.0	134.5	129.5	146.0	148.0	147.5	(a)
4	-----	-----	-----	-----	-----	(a)	139.0	129.5	135.0	146.5	146.0	-----
5	-----	-----	-----	-----	-----	-----	133.0	136.0	133.0	138.5	139.0	-----
6	-----	-----	-----	-----	-----	-----	129.0	128.0	136.5	131.0	(a)	-----
7	-----	-----	-----	-----	-----	-----	(a)	(a)	(a)	(a)	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(c) M = 0.85, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	142.5	149.0	154.0	152.5	154.0	150.0	146.5	145.0	146.0
2	-----	-----	-----	(a)	137.0	137.0	144.0	148.5	151.5	150.5	151.5	138.0
3	-----	-----	-----	-----	(a)	133.5	136.0	133.5	146.5	150.5	150.5	138.5
4	-----	-----	-----	-----	-----	(a)	138.5	137.0	133.0	146.0	147.0	136.5
5	-----	-----	-----	-----	-----	-----	(a)	133.0	138.0	133.0	139.0	132.0
6	-----	-----	-----	-----	-----	-----	-----	(a)	135.5	135.0	132.0	(a)
7	-----	-----	-----	-----	-----	-----	-----	-----	131.0	137.0	138.5	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	(a)	131.0	136.0	-----

[a]Not visible above tunnel background noise.

TABLE III. - Continued.

(g) M = 0.8, J = 2.83

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	140.5	142.5	145.5	149.5	155.0	151.5	160.5	160.5	155.0	157.5	156.0	147.5
2	(a)	(a)	(a)	138.5	144.5	151.0	144.5	149.0	153.5	153.5	151.0	141.0
3	-----	-----	-----	130.0	134.0	140.5	148.0	147.0	130.5	143.5	144.5	135.0
4	-----	-----	-----	(a)	129.0	136.0	142.0	135.5	143.5	140.0	141.5	131.5
5	-----	-----	-----	-----	(a)	(a)	135.0	136.0	137.0	138.0	138.5	132.0
6	-----	-----	-----	-----	-----	-----	130.0	134.0	134.5	137.0	135.0	128.0
7	-----	-----	-----	-----	-----	-----	135.5	126.5	122.0	139.0	137.5	124.0
8	-----	-----	-----	-----	-----	-----	128.5	129.5	128.0	136.0	137.0	(a)

(h) M = 0.75, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	139.0	136.0	135.5	140.5	147.5	152.0	148.5	146.0	140.5	132.5	135.0	132.5
2	(a)	(a)	(a)	136.5	143.5	148.5	146.0	142.0	136.5	134.0	(a)	(a)
3	-----	-----	-----	(a)	139.5	142.5	143.0	134.5	(a)	(a)	-----	-----
4	-----	-----	-----	-----	133.0	139.0	139.0	132.0	-----	-----	-----	-----
5	-----	-----	-----	-----	(a)	137.0	135.5	129.0	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	134.5	135.0	127.0	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	130.0	133.0	(a)	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	126.5	130.0	(a)	-----	-----	-----	-----

(i) M = 0.75, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	143.0	143.5	144.5	143.0	150.5	156.0	153.5	151.0	148.5	148.0	145.0	146.0
2	(a)	(a)	(a)	137.5	144.0	150.5	149.5	149.5	139.0	139.5	139.0	139.5
3	-----	-----	-----	(a)	138.5	145.0	144.0	143.5	143.0	133.0	135.5	137.5
4	-----	-----	-----	-----	133.0	142.0	138.5	136.5	134.5	131.0	(a)	132.5
5	-----	-----	-----	-----	128.5	139.0	137.0	134.0	130.5	(a)	-----	(a)
6	-----	-----	-----	-----	(a)	135.0	137.5	134.0	(a)	-----	-----	-----
7	-----	-----	-----	-----	-----	132.0	133.5	133.0	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	129.0	130.0	130.0	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE III. – Continued.

(j) M = 0.75, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	140.0	144.0	140.5	147.5	151.5	158.5	156.0	152.0	151.5	152.5	152.0	139.5
2	(a)	(a)	(a)	137.0	143.0	150.0	149.5	148.5	148.5	142.0	136.5	137.5
3	-----	-----	-----	(a)	139.0	145.0	143.0	143.5	141.5	137.5	134.5	(a)
4	-----	-----	-----	-----	133.0	142.5	141.5	138.0	138.0	132.5	(a)	-----
5	-----	-----	-----	-----	(a)	139.5	140.5	137.5	128.0	(a)	-----	-----
6	-----	-----	-----	-----	-----	135.0	138.0	135.5	130.0	-----	-----	-----
7	-----	-----	-----	-----	-----	131.0	132.5	134.0	131.5	-----	-----	-----
8	-----	-----	-----	-----	-----	127.5	131.5	128.5	132.0	-----	-----	-----

(k) M = 0.75, J = 2.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	148.0	146.0	140.5	145.5	146.5	160.5	161.0	160.0	154.0	155.5	152.5	153.5
2	(a)	(a)	(a)	(a)	143.5	155.0	153.5	154.0	155.5	149.0	150.0	139.0
3	-----	-----	-----	-----	135.0	148.0	145.0	143.0	148.0	145.0	143.5	137.5
4	-----	-----	-----	-----	(a)	146.0	148.5	145.0	136.0	133.5	136.5	137.0
5	-----	-----	-----	-----	-----	141.0	140.0	143.5	138.0	137.0	132.0	127.0
6	-----	-----	-----	-----	-----	137.0	135.0	135.0	140.0	132.0	131.5	130.0
7	-----	-----	-----	-----	-----	133.0	135.0	126.5	138.0	134.0	131.0	129.0
8	-----	-----	-----	-----	-----	(a)	132.5	128.0	132.5	131.5	130.0	125.0

(l) M = 0.7, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	139.5	144.0	145.0	137.0	137.0	134.5	135.0	133.0	130.0
2	-----	-----	-----	(a)	134.0	141.0	137.0	(a)	(a)	(a)	(a)	(a)
3	-----	-----	-----	-----	(a)	138.0	(a)	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	135.0	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	(a)	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE III. - Continued.

(m) M = 0.7, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	141.5	141.0	139.5	148.0	150.0	151.0	150.0	149.5	149.0	141.5	137.5	139.0
2	(a)	(a)	(a)	138.5	142.5	146.5	146.0	143.0	137.5	136.0	137.5	135.0
3	-----	-----	-----	133.0	138.0	144.5	141.0	139.5	132.5	135.0	(a)	(a)
4	-----	-----	-----	(a)	135.0	137.5	136.5	132.5	129.5	130.5	-----	-----
5	-----	-----	-----	-----	131.5	135.5	133.5	128.0	(a)	(a)	-----	-----
6	-----	-----	-----	-----	127.0	134.0	128.5	125.0	-----	-----	-----	-----
7	-----	-----	-----	-----	124.0	131.5	128.0	(a)	-----	-----	-----	-----
8	-----	-----	-----	-----	(a)	130.0	127.0	-----	-----	-----	-----	-----

(n) M = 0.7, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	140.5	145.0	145.0	150.0	147.5	150.5	148.0	148.0	150.0	147.0	144.0	140.0
2	(a)	137.0	134.0	139.0	143.5	151.0	150.0	148.0	140.5	136.5	134.0	133.5
3	-----	(a)	(a)	133.0	141.5	144.0	143.0	142.0	140.0	134.0	134.0	134.5
4	-----	-----	-----	132.0	136.5	140.5	138.0	136.0	134.5	129.0	133.0	(a)
5	-----	-----	-----	(a)	132.0	137.0	134.0	131.0	129.0	127.0	130.5	-----
6	-----	-----	-----	-----	130.0	137.5	134.5	128.0	(a)	(a)	(a)	-----
7	-----	-----	-----	-----	126.0	135.0	134.5	128.0	-----	-----	-----	-----
8	-----	-----	-----	-----	(a)	132.0	132.0	125.0	-----	-----	-----	-----

(o) M = 0.7, J = 2.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	143.5	144.0	148.0	144.0	154.0	159.0	158.0	158.0	157.5	148.0	146.0	146.0
2	138.5	137.5	138.0	144.0	147.5	152.5	152.0	151.0	149.0	144.0	138.5	144.0
3	(a)	(a)	131.5	135.0	144.0	147.5	146.5	147.5	145.5	141.0	137.5	137.5
4	-----	-----	(a)	132.0	140.0	143.0	136.0	131.0	138.0	134.5	136.5	135.5
5	-----	-----	-----	(a)	134.5	141.0	140.5	136.0	128.0	133.5	131.5	131.5
6	-----	-----	-----	-----	131.5	138.0	139.0	135.0	131.0	129.0	130.0	126.0
7	-----	-----	-----	-----	128.0	137.0	136.0	133.0	134.0	130.0	129.5	126.0
8	-----	-----	-----	-----	(a)	135.0	134.0	132.0	128.0	(a)	127.5	127.0

[a]Not visible above tunnel background noise.

TABLE III. - Continued.

(p) M = 0.65, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	133.0	136.0	138.0	135.5	134.0	131.5	(a)	(a)	(a)
2	-----	-----	-----	(a)	128.0	128.5	(a)	(a)	(a)	-----	-----	-----
3	-----	-----	-----	-----	(a)	(a)	-----	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(q) M = 0.65, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	134.0	131.0	133.0	134.5	139.5	142.0	139.0	137.0	133.5	132.5	133.5	136.5
2	(a)	(a)	(a)	130.0	133.5	136.5	134.0	129.5	127.5	(a)	(a)	(a)
3	-----	-----	-----	(a)	(a)	(a)	(a)	(a)	(a)	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(r) M = 0.65, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	143.5	147.0	148.5	142.5	140.5	141.0	139.0	136.0	135.5
2	-----	-----	-----	(a)	137.0	143.0	142.0	141.0	138.0	132.0	(a)	(a)
3	-----	-----	-----	-----	133.5	138.5	136.5	134.0	132.0	133.0	-----	-----
4	-----	-----	-----	-----	129.0	132.5	131.0	128.0	(a)	(a)	-----	-----
5	-----	-----	-----	-----	126.0	128.0	127.5	126.0	-----	-----	-----	-----
6	-----	-----	-----	-----	(a)	126.0	(a)	(a)	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	123.0	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	120.0	-----	-----	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE III. - Continued.

(s) M = 0.65, J = 2.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	141.5	142.0	142.5	143.5	152.5	156.5	154.5	152.5	148.0	145.0	146.5	141.5
2	137.0	135.5	140.0	140.5	143.0	152.5	152.5	150.0	144.0	140.0	142.5	139.5
3	135.5	135.0	132.0	135.5	145.5	148.0	146.5	145.0	140.5	131.5	133.0	134.5
4	(a)	(a)	129.5	130.5	142.5	144.5	142.0	141.0	133.0	134.5	136.5	128.5
5	-----	-----	(a)	128.0	136.5	140.0	135.0	132.0	125.0	126.5	130.0	127.0
6	-----	-----	-----	125.0	133.5	138.5	133.5	130.0	124.0	126.5	127.0	127.0
7	-----	-----	-----	122.0	132.0	135.5	131.0	127.5	121.0	124.0	122.0	123.0
8	-----	-----	-----	119.0	130.0	134.0	131.0	123.0	(a)	121.0	120.5	(a)

(t) M = 0.6, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(u) M = 0.6, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	132.5	136.0	138.5	137.0	135.5	132.5	129.0	129.0	(a)
2	-----	-----	-----	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	-----
3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE III. - Continued.

(v) M = 0.6, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	134.5	136.5	140.0	142.5	142.0	141.0	139.0	136.0	134.5	(a)
2	-----	-----	(a)	128.0	129.0	132.0	131.0	129.5	(a)	(a)	(a)	-----
3	-----	-----	-----	(a)	(a)	(a)	(a)	(a)	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(w) M = 0.6, J = 2.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	136.5	134.5	134.5	144.5	148.0	149.5	148.5	147.5	145.5	140.0	135.5	140.0
2	(a)	(a)	(a)	133.0	136.0	141.5	139.0	137.5	134.5	132.5	132.0	(a)
3	-----	-----	-----	(a)	133.5	138.5	135.0	131.5	131.5	(a)	(a)	-----
4	-----	-----	-----	-----	127.5	131.0	125.0	123.0	126.0	-----	-----	-----
5	-----	-----	-----	-----	123.0	126.5	(a)	(a)	(a)	-----	-----	-----
6	-----	-----	-----	-----	(a)	122.5	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	119.0	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	(a)	-----	-----	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE IV. - NOISE DATA AT 60.1° BLADE ANGLE

(a) M = 0.9, J = windmill = 3.72

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	135.0	144.5	149.0	149.0	151.5	149.0	141.5	145.5	142.5
2	-----	-----	-----	(a)	(a)	(a)	133.5	136.5	141.0	140.0	141.0	139.0
3	-----	-----	-----	-----	-----	-----	141.0	141.0	141.0	144.5	143.5	136.0
4	-----	-----	-----	-----	-----	-----	137.0	136.0	142.0	145.0	144.5	(a)
5	-----	-----	-----	-----	-----	-----	(a)	135.0	137.0	143.0	143.0	-----
6	-----	-----	-----	-----	-----	-----	-----	128.0	133.0	137.5	139.5	-----
7	-----	-----	-----	-----	-----	-----	-----	123.5	136.5	132.0	136.0	-----
8	-----	-----	-----	-----	-----	-----	-----	(a)	131.0	123.0	126.0	-----

(b) M = 0.9, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	136.5	145.0	153.0	148.0	153.0	151.0	146.0	139.0	140.0
2	-----	-----	-----	(a)	134.5	142.0	134.0	143.0	144.5	145.5	146.0	140.5
3	-----	-----	-----	-----	(a)	133.0	138.0	139.0	142.5	146.5	146.0	140.5
4	-----	-----	-----	-----	-----	126.0	137.5	132.0	141.5	146.5	147.5	141.0
5	-----	-----	-----	-----	-----	(a)	(a)	134.5	132.0	141.5	144.0	135.0
6	-----	-----	-----	-----	-----	-----	-----	134.0	135.0	134.0	139.0	133.0
7	-----	-----	-----	-----	-----	-----	-----	127.0	136.0	123.0	128.0	(a)
8	-----	-----	-----	-----	-----	-----	-----	120.0	130.0	132.5	130.0	(a)

(c) M = 0.9, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	138.5	148.0	157.5	157.0	158.5	157.0	150.5	149.5	142.5
2	-----	-----	-----	(a)	137.5	148.5	134.5	144.5	147.0	150.0	150.5	147.5
3	-----	-----	-----	-----	131.5	143.0	136.0	138.5	143.5	149.5	150.0	147.0
4	-----	-----	-----	-----	(a)	137.5	127.5	136.5	137.0	145.0	147.0	143.5
5	-----	-----	-----	-----	-----	133.0	(a)	134.0	136.0	138.0	141.5	139.5
6	-----	-----	-----	-----	-----	129.0	-----	121.0	136.5	124.0	130.0	135.0
7	-----	-----	-----	-----	-----	(a)	-----	127.0	134.0	132.5	136.0	128.0
8	-----	-----	-----	-----	-----	-----	-----	122.0	130.0	131.0	135.0	126.0

[a]Not visible above tunnel background noise.

TABLE IV. - Continued.

(d) M = 0.9, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	139.0	148.0	157.5	162.0	162.0	159.5	157.0	155.5	152.5
2	-----	-----	-----	(a)	139.0	148.5	144.5	148.5	148.5	152.0	153.0	149.0
3	-----	-----	-----	-----	133.0	144.5	141.0	147.5	146.0	150.5	152.0	145.0
4	-----	-----	-----	-----	128.0	140.5	141.5	134.5	137.5	143.5	147.0	142.0
5	-----	-----	-----	-----	123.0	136.0	136.5	133.5	138.5	126.5	136.0	136.0
6	-----	-----	-----	-----	(a)	132.5	134.0	130.0	137.5	134.0	137.0	132.0
7	-----	-----	-----	-----	-----	130.0	130.5	122.0	131.5	131.0	137.0	134.0
8	-----	-----	-----	-----	-----	126.0	121.0	(a)	131.0	126.0	130.0	130.0

(e) M = 0.85, J = 3.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	130.5	139.5	152.5	156.0	154.5	144.0	145.0	135.0	143.0
2	-----	-----	-----	(a)	(a)	141.5	145.5	151.0	150.0	147.0	140.0	135.5
3	-----	-----	-----	-----	-----	(a)	145.3	134.0	145.5	145.0	139.5	(a)
4	-----	-----	-----	-----	-----	-----	132.5	143.5	132.0	137.5	136.0	-----
5	-----	-----	-----	-----	-----	-----	(a)	(a)	141.0	132.0	133.5	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	138.0	136.0	132.0	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	125.0	134.0	131.5	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	129.5	130.0	128.0	-----

(f) M = 0.85, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	136.5	146.0	153.5	157.5	156.5	151.5	151.5	147.0	143.5
2	-----	-----	-----	(a)	(a)	145.5	146.0	152.0	153.5	151.0	149.5	136.5
3	-----	-----	-----	-----	-----	137.0	148.0	141.5	144.0	147.0	144.0	135.0
4	-----	-----	-----	-----	-----	130.5	136.0	142.0	140.0	138.5	138.0	135.0
5	-----	-----	-----	-----	-----	(a)	133.0	134.0	141.0	134.5	133.0	132.0
6	-----	-----	-----	-----	-----	-----	131.0	132.0	132.0	136.0	135.0	130.0
7	-----	-----	-----	-----	-----	-----	(a)	128.5	130.0	134.0	133.0	125.0
8	-----	-----	-----	-----	-----	-----	(a)	127.0	128.5	131.5	129.0	123.5

[a]Not visible above tunnel background noise.

TABLE IV. - Continued.

(g) M = 0.85, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	142.0	150.0	155.0	156.0	158.0	157.0	151.5	155.0	142.5
2	-----	-----	-----	(a)	140.0	136.0	143.5	149.5	154.0	153.5	151.5	141.5
3	-----	-----	-----	-----	(a)	(a)	146.5	145.5	140.5	150.0	150.0	138.0
4	-----	-----	-----	-----	-----	-----	139.0	135.5	142.0	133.5	138.0	131.5
5	-----	-----	-----	-----	-----	-----	(a)	139.0	140.0	142.0	138.5	128.5
6	-----	-----	-----	-----	-----	-----	-----	(a)	130.0	141.5	141.0	130.0
7	-----	-----	-----	-----	-----	-----	-----	-----	134.0	135.0	138.0	127.5
8	-----	-----	-----	-----	-----	-----	-----	-----	121.0	135.0	133.5	(a)

(h) M = 0.85, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	143.0	151.0	155.5	159.5	160.5	159.0	154.0	156.5	147.0
2	-----	-----	-----	(a)	141.5	146.5	143.5	149.0	155.5	156.5	156.0	137.5
3	-----	-----	-----	-----	132.5	141.0	145.0	147.5	133.5	148.5	148.0	132.0
4	-----	-----	-----	-----	127.0	134.5	143.5	133.5	146.0	138.0	138.0	137.5
5	-----	-----	-----	-----	(a)	128.5	132.0	139.0	137.0	143.0	140.5	132.0
6	-----	-----	-----	-----	-----	(a)	(a)	132.0	135.0	142.0	143.0	134.5
7	-----	-----	-----	-----	-----	-----	-----	(a)	128.0	134.5	140.0	127.0
8	-----	-----	-----	-----	-----	-----	-----	-----	127.5	136.0	135.0	123.0

(i) M = 0.8, J = windmill = 4.1

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE IV. - Continued.

(j) M = 0.8, J = 3.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	135.0	135.0	135.0	139.0	145.5	149.5	154.0	150.5	145.0	147.0	142.5	138.0
2	(a)	(a)	(a)	(a)	138.0	138.5	148.0	146.5	146.0	134.5	136.0	137.5
3	-----	-----	-----	-----	(a)	(a)	144.0	144.0	141.5	(a)	(a)	(a)
4	-----	-----	-----	-----	-----	-----	140.0	136.0	135.0	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	138.0	137.0	130.0	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	136.0	134.5	127.0	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	130.0	132.5	127.0	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	129.0	128.0	128.0	-----	-----	-----

(k) M = 0.8, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	142.5	142.5	140.0	144.5	150.0	156.5	157.5	156.0	148.0	152.0	152.5	142.0
2	(a)	(a)	(a)	(a)	137.0	147.5	148.5	149.5	147.5	146.0	141.0	139.0
3	-----	-----	-----	-----	(a)	144.0	143.0	143.0	143.5	139.5	137.0	134.5
4	-----	-----	-----	-----	-----	140.0	143.5	138.5	138.5	130.5	132.5	132.0
5	-----	-----	-----	-----	-----	(a)	139.0	139.0	131.0	130.5	128.0	130.5
6	-----	-----	-----	-----	-----	-----	133.0	135.0	133.0	(a)	(a)	(a)
7	-----	-----	-----	-----	-----	-----	132.5	130.0	133.5	(a)	-----	-----
8	-----	-----	-----	-----	-----	-----	129.5	128.0	131.0	(a)	-----	-----

(l) M = 0.8, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	143.5	143.0	142.0	143.0	149.5	157.5	160.5	159.5	155.0	149.5	147.5	147.0
2	(a)	(a)	(a)	(a)	135.5	148.0	150.5	151.5	152.5	148.0	145.0	138.0
3	-----	-----	-----	-----	(a)	145.5	146.5	142.0	145.0	142.0	141.0	(a)
4	-----	-----	-----	-----	-----	140.0	146.0	143.0	134.5	131.5	135.5	134.5
5	-----	-----	-----	-----	-----	133.5	137.0	141.0	135.5	131.0	(a)	128.5
6	-----	-----	-----	-----	-----	(a)	135.0	130.0	139.0	131.5	130.0	131.0
7	-----	-----	-----	-----	-----	-----	133.5	128.0	136.5	130.0	127.5	(a)
8	-----	-----	-----	-----	-----	-----	(a)	128.5	131.5	131.5	128.0	(a)

[a]Not visible above tunnel background noise.

TABLE IV. - Continued.

(m) M = 0.8, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	142.0	140.5	142.0	144.5	153.0	156.5	162.5	161.5	160.5	158.0	155.0	150.5
2	(a)	(a)	(a)	(a)	138.0	148.0	147.5	151.0	154.0	152.5	150.5	138.5
3	-----	-----	-----	-----	132.0	143.5	148.5	142.5	144.0	146.5	147.5	138.0
4	-----	-----	-----	-----	(a)	139.0	146.0	145.0	136.0	137.0	136.5	135.5
5	-----	-----	-----	-----	-----	(a)	134.0	139.5	141.0	133.0	129.5	132.0
6	-----	-----	-----	-----	-----	-----	132.5	128.0	139.0	136.5	133.0	130.0
7	-----	-----	-----	-----	-----	-----	132.0	126.5	134.0	134.0	133.0	124.5
8	-----	-----	-----	-----	-----	-----	(a)	123.0	132.0	131.5	128.0	127.0

(n) M = 0.8, J = 2.82

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	140.5	142.0	144.0	149.5	153.0	161.5	166.5	165.5	161.0	162.0	162.5	151.5
2	(a)	(a)	(a)	139.0	147.0	145.0	151.0	153.5	157.0	157.5	153.5	147.0
3	-----	-----	-----	131.0	140.0	145.0	149.5	148.0	146.0	149.5	148.5	135.5
4	-----	-----	-----	(a)	133.5	137.0	142.5	143.5	142.5	139.0	139.5	134.0
5	-----	-----	-----	-----	128.0	(a)	142.0	134.0	142.5	142.0	142.0	135.0
6	-----	-----	-----	-----	(a)	-----	133.0	133.5	138.0	143.5	141.0	128.0
7	-----	-----	-----	-----	-----	-----	130.0	123.0	134.5	138.0	137.0	125.0
8	-----	-----	-----	-----	-----	-----	130.5	128.0	134.0	136.0	130.0	(a)

(o) M = 0.75, J = 3.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	144.0	149.0	152.0	148.5	147.0	145.5	141.0	137.5	138.5
2	-----	-----	-----	135.5	140.5	144.5	144.0	141.0	137.0	133.0	131.0	134.0
3	-----	-----	-----	(a)	(a)	143.5	142.0	139.5	(a)	(a)	(a)	(a)
4	-----	-----	-----	-----	-----	137.0	136.5	135.0	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	134.0	131.5	(a)	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	132.0	128.0	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	130.0	129.5	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	127.5	127.0	-----	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE IV. - Continued.

(p) M = 0.75, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	141.0	138.0	133.5	143.0	147.5	152.5	150.0	147.0	148.0	143.5	137.5	136.5
2	(a)	(a)	(a)	133.0	143.5	150.5	149.0	147.0	143.0	132.5	132.5	131.5
3	-----	-----	-----	(a)	138.0	144.0	143.5	141.5	136.0	(a)	(a)	(a)
4	-----	-----	-----	-----	133.5	139.0	136.0	134.5	130.5	-----	-----	-----
5	-----	-----	-----	-----	(a)	137.0	134.0	130.0	(a)	-----	-----	-----
6	-----	-----	-----	-----	-----	135.0	134.0	130.0	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	132.0	134.0	129.0	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	129.0	130.0	127.0	-----	-----	-----	-----

(q) M = 0.75, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	144.0	143.5	144.0	143.5	149.5	157.0	156.5	155.0	154.0	151.5	148.5	146.5
2	(a)	(a)	137.0	138.5	143.5	152.5	153.0	152.0	144.0	145.5	139.0	143.5
3	-----	-----	(a)	(a)	137.0	146.0	143.5	144.0	144.0	138.5	138.0	137.0
4	-----	-----	-----	-----	132.5	143.0	138.0	130.5	135.0	132.5	130.0	134.0
5	-----	-----	-----	-----	129.0	141.0	141.0	136.5	129.5	128.5	132.0	129.0
6	-----	-----	-----	-----	(a)	137.0	139.0	136.0	127.0	126.0	(a)	127.0
7	-----	-----	-----	-----	-----	133.0	134.5	131.5	129.0	(a)	-----	(a)
8	-----	-----	-----	-----	-----	130.0	134.0	131.0	124.0	-----	-----	-----

(r) M = 0.75, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	140.5	142.5	140.5	146.5	151.5	159.5	160.5	158.0	153.0	157.5	157.5	143.0
2	(a)	(a)	(a)	136.5	143.0	152.5	153.0	153.0	151.0	149.5	139.5	140.0
3	-----	-----	-----	(a)	140.0	146.5	143.5	147.0	146.5	137.5	141.0	138.0
4	-----	-----	-----	-----	133.0	143.5	141.0	133.0	140.0	138.5	131.0	136.5
5	-----	-----	-----	-----	(a)	139.5	141.0	138.0	130.0	129.0	129.0	128.5
6	-----	-----	-----	-----	-----	135.5	137.0	135.0	131.5	129.0	130.0	126.5
7	-----	-----	-----	-----	-----	133.5	135.5	132.5	130.0	125.0	(a)	126.0
8	-----	-----	-----	-----	-----	130.0	135.0	129.0	130.5	126.0	-----	125.0

[a]Not visible above tunnel background noise.

TABLE IV. – Continued.

(s) M = 0.75, J = 2.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	146.5	145.0	140.0	150.5	152.0	163.5	165.0	163.5	160.5	158.5	155.0	156.5
2	(a)	(a)	137.5	142.5	147.0	157.5	157.5	158.0	159.0	152.0	152.5	142.0
3	-----	-----	(a)	132.5	138.5	152.5	143.0	147.0	150.5	147.0	147.0	141.0
4	-----	-----	-----	128.5	128.0	147.5	147.0	146.0	139.5	142.5	140.0	139.0
5	-----	-----	-----	(a)	(a)	143.0	139.5	142.5	142.0	143.0	140.0	131.0
6	-----	-----	-----	-----	-----	139.0	139.0	131.5	140.0	133.0	134.0	132.5
7	-----	-----	-----	-----	-----	136.0	136.0	135.0	135.0	136.0	136.0	126.0
8	-----	-----	-----	-----	-----	132.0	134.5	128.5	134.0	132.5	131.5	129.0

(t) M = 0.7, J = 3.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(u) M = 0.7, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	129.5	140.0	145.5	148.0	141.0	134.5	139.0	141.0	139.5	132.5
2	-----	-----	(a)	133.5	134.5	144.0	141.0	137.5	137.5	(a)	(a)	(a)
3	-----	-----	-----	(a)	(a)	139.5	137.5	135.5	(a)	-----	-----	-----
4	-----	-----	-----	-----	-----	135.0	132.5	130.0	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	130.0	129.0	(a)	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	128.5	126.0	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	126.0	(a)	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	122.5	-----	-----	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE IV. - Continued.

(v) $M = 0.7$, $J = 3.25$

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	143.5	144.0	141.0	150.5	152.5	155.0	155.0	154.0	152.0	147.5	143.5	143.0
2	(a)	(a)	136.0	139.0	143.5	149.5	149.5	146.0	140.0	142.0	139.5	137.0
3	-----	-----	(a)	134.0	140.0	146.5	143.5	142.5	136.5	136.5	136.0	133.0
4	-----	-----	-----	129.0	137.0	139.5	138.0	132.5	129.0	131.5	131.0	(a)
5	-----	-----	-----	126.0	131.0	138.0	132.5	129.5	127.0	128.0	(a)	-----
6	-----	-----	-----	(a)	128.0	133.0	127.0	123.0	124.0	(a)	-----	-----
7	-----	-----	-----	-----	126.0	131.0	127.5	(a)	(a)	-----	-----	-----
8	-----	-----	-----	-----	122.0	130.0	126.0	-----	-----	-----	-----	-----

(w) $M = 0.7$, $J = 3.06$

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	145.0	149.0	148.0	152.0	150.0	154.0	153.5	153.5	154.5	151.0	147.5	140.5
2	(a)	138.0	136.5	140.5	145.5	154.0	152.5	151.0	148.0	137.5	136.0	137.0
3	-----	134.5	133.0	134.5	143.5	148.5	148.0	146.5	144.0	137.0	137.5	136.0
4	-----	(a)	(a)	132.0	138.5	144.0	141.6	139.0	135.0	136.5	133.5	128.5
5	-----	-----	-----	(a)	134.0	138.5	134.0	131.0	130.0	130.5	133.0	(a)
6	-----	-----	-----	-----	132.0	138.0	134.0	127.0	126.0	127.0	(a)	-----
7	-----	-----	-----	-----	127.0	134.0	133.0	127.0	125.0	123.0	-----	-----
8	-----	-----	-----	-----	(a)	131.0	130.0	(a)	(a)	(a)	-----	-----

(x) $M = 0.7$, $J = 2.75$

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	144.0	145.0	150.5	147.5	157.0	163.0	162.0	161.5	161.0	156.5	153.0	146.0
2	140.0	140.0	139.0	141.5	148.5	155.5	156.0	155.0	153.5	151.0	147.0	145.0
3	(a)	(a)	134.0	134.5	144.5	147.5	147.0	148.0	149.0	139.0	142.0	139.0
4	-----	-----	(a)	131.0	139.0	146.5	143.0	138.0	140.0	134.5	139.0	139.0
5	-----	-----	-----	(a)	137.0	143.0	143.0	143.0	137.0	140.0	135.0	130.0
6	-----	-----	-----	-----	133.0	139.5	138.0	136.5	139.5	133.0	129.0	131.0
7	-----	-----	-----	-----	128.0	137.0	136.5	132.0	133.0	125.0	133.0	131.5
8	-----	-----	-----	-----	(a)	132.0	133.0	132.5	137.0	(a)	127.0	127.0

[a]Not visible above tunnel background noise.

TABLE IV. - Continued.

(y) M = 0.65, J = 3.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(z) M = 0.65, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	135.5	140.0	143.0	141.5	140.0	137.5	133.5	132.5	(a)
2	-----	-----	-----	(a)	130.5	131.0	128.0	(a)	(a)	(a)	(a)	-----
3	-----	-----	-----	-----	(a)	(a)	(a)	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(aa) M = 0.65, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	135.5	132.0	134.0	136.0	141.5	145.0	142.0	140.0	137.5	137.5	136.5	139.0
2	(a)	(a)	(a)	133.0	136.0	139.0	137.5	135.0	(a)	(a)	(a)	(a)
3	-----	-----	-----	(a)	(a)	133.5	(a)	(a)	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	(a)	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE IV. - Continued.

(bb) M = 0.65, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	137.0	136.0	136.0	145.5	151.0	153.5	149.0	144.0	142.0	145.0	144.0	137.0
2	139.0	139.0	138.5	134.5	141.0	146.5	144.5	143.0	142.0	138.5	134.5	133.5
3	(a)	(a)	(a)	(a)	135.5	141.5	137.0	134.5	132.0	135.0	133.5	(a)
4	-----	-----	-----	-----	133.5	137.5	135.5	131.0	126.0	130.0	(a)	-----
5	-----	-----	-----	-----	128.5	134.5	129.0	127.0	(a)	(a)	-----	-----
6	-----	-----	-----	-----	127.0	134.0	128.0	125.0	-----	-----	-----	-----
7	-----	-----	-----	-----	122.0	129.0	(a)	(a)	-----	-----	-----	-----
8	-----	-----	-----	-----	(a)	126.0	-----	-----	-----	-----	-----	-----

(cc) M = 0.65, J = 2.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	144.5	147.0	145.0	140.5	152.0	157.5	156.5	155.0	153.0	152.5	152.5	146.0
2	139.0	135.5	135.5	140.0	140.5	152.0	153.5	152.0	146.0	140.0	136.5	138.0
3	135.5	135.0	133.0	138.5	144.5	148.5	145.5	143.5	140.0	134.5	139.0	134.0
4	(a)	131.0	127.0	129.5	142.0	145.0	143.5	140.5	133.0	133.0	138.5	129.0
5	-----	(a)	(a)	131.0	135.5	141.5	138.0	134.0	125.0	128.0	127.0	131.0
6	-----	-----	-----	125.0	133.0	139.0	135.0	133.5	124.0	123.0	126.0	130.0
7	-----	-----	-----	122.0	132.5	136.0	132.0	128.0	123.0	125.5	124.5	125.0
8	-----	-----	-----	(a)	130.0	135.0	134.0	125.0	122.5	120.0	122.0	121.0

(dd) M = 0.6, J = 3.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE IV. - Continued.

(ee) M = 0.60, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(ff) M = 0.6, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	135.0	139.5	143.0	142.0	140.0	136.5	132.0	131.0	(a)
2	-----	-----	-----	(a)	(a)	126.5	(a)	(a)	(a)	(a)	(a)	-----
3	-----	-----	-----	-----	-----	(a)	-----	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(gg) M = 0.60, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	135.0	139.0	143.5	146.5	147.0	145.5	143.5	140.0	138.0	137.0
2	-----	-----	(a)	(a)	126.0	132.0	131.0	128.0	(a)	(a)	(a)	(a)
3	-----	-----	-----	-----	(a)	(a)	(a)	(a)	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE IV. - Continued.

(hh) M = 0.60, J = 2.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	139.0	137.0	138.5	145.5	150.0	152.0	151.0	150.0	148.5	143.5	139.0	141.5
2	(a)	(a)	(a)	131.5	137.0	143.5	142.5	141.0	137.5	135.0	133.5	128.5
3	-----	-----	-----	(a)	132.0	137.5	133.0	129.5	131.0	132.0	128.5	(a)
4	-----	-----	-----	-----	130.0	130.0	125.5	124.5	(a)	129.5	125.5	(a)
5	-----	-----	-----	-----	122.0	125.0	(a)	(a)	-----	(a)	(a)	-----
6	-----	-----	-----	-----	(a)	124.0	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	120.0	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	(a)	-----	-----	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE V. - NOISE DATA AT 63.3° BLADE ANGLE

(a) M = 0.9, J = 4.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	133.5	141.5	146.0	146.5	147.0	142.5	139.0	140.0	132.0
2	-----	-----	-----	(a)	(a)	(a)	139.5	146.0	145.5	143.5	144.0	(a)
3	-----	-----	-----	-----	-----	-----	139.5	139.5	144.5	144.5	143.5	-----
4	-----	-----	-----	-----	-----	-----	135.5	133.0	141.5	143.5	142.5	-----
5	-----	-----	-----	-----	-----	-----	(a)	132.0	129.0	138.0	139.0	-----
6	-----	-----	-----	-----	-----	-----	-----	130.5	128.0	131.0	134.5	-----
7	-----	-----	-----	-----	-----	-----	-----	125.0	132.0	126.0	126.0	-----
8	-----	-----	-----	-----	-----	-----	-----	124.0	127.5	131.5	131.0	-----

(b) M = 0.9, J ≈ 4.0

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	143.0	150.0	141.0	148.0	146.5	141.0	136.0	141.0
2	-----	-----	-----	-----	(a)	(a)	143.0	148.0	148.5	147.0	147.0	(a)
3	-----	-----	-----	-----	-----	-----	(a)	138.0	145.0	146.5	145.5	-----
4	-----	-----	-----	-----	-----	-----	-----	(a)	138.5	143.0	143.5	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	130.0	135.5	138.0	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	133.5	128.0	132.0	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	130.5	132.0	131.5	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	(a)	132.0	133.5	-----

(c) M = 0.9, J ≈ 3.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	135.0	143.5	154.5	145.5	152.5	151.5	146.5	148.0	141.5
2	-----	-----	-----	(a)	(a)	142.5	145.5	147.5	149.0	149.0	149.0	140.0
3	-----	-----	-----	-----	-----	138.0	133.0	137.0	145.0	147.5	147.5	135.5
4	-----	-----	-----	-----	-----	(a)	135.0	133.5	134.5	142.0	143.0	131.5
5	-----	-----	-----	-----	-----	-----	(a)	134.0	133.5	133.0	135.5	(a)
6	-----	-----	-----	-----	-----	-----	-----	(a)	133.5	133.0	134.0	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	123.0	134.5	136.0	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	125.0	133.0	136.0	-----

[a]Not visible above tunnel background noise.

TABLE V. - Continued.

(d) $M = 0.9$, $J = 3.5$

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	135.0	144.0	156.0	156.0	157.5	156.0	153.5	150.0	147.0
2	-----	-----	-----	(a)	134.0	146.0	138.5	145.5	151.0	152.5	152.0	140.0
3	-----	-----	-----	-----	(a)	139.0	136.5	137.5	142.0	148.5	149.0	139.5
4	-----	-----	-----	-----	-----	132.5	136.0	134.0	128.5	138.0	140.5	134.5
5	-----	-----	-----	-----	-----	128.5	128.5	132.0	133.0	135.0	135.0	130.0
6	-----	-----	-----	-----	-----	(a)	(a)	(a)	(a)	139.0	139.0	(a)
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	135.0	137.0	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	126.0	133.5	-----

(e) $M = 0.9$, $J = 3.25$

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	136.5	146.0	156.0	162.5	162.5	161.5	158.5	157.5	152.5
2	-----	-----	-----	(a)	137.0	146.0	148.5	151.0	153.0	155.0	155.0	150.5
3	-----	-----	-----	-----	131.0	141.0	146.0	149.5	140.0	149.0	151.0	145.5
4	-----	-----	-----	-----	126.0	136.5	136.0	139.5	142.0	132.5	137.5	137.5
5	-----	-----	-----	-----	(a)	132.5	129.0	135.0	130.5	141.5	142.0	132.0
6	-----	-----	-----	-----	-----	130.5	127.0	134.0	136.0	140.0	143.0	133.0
7	-----	-----	-----	-----	-----	128.0	127.0	130.5	131.0	125.0	135.0	127.5
8	-----	-----	-----	-----	-----	(a)	(a)	(a)	124.5	131.0	132.0	122.5

(f) $M = 0.9$, $J = 3.06$

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	136.5	145.0	154.0	164.0	165.0	163.5	161.5	159.5	157.0
2	-----	-----	-----	(a)	138.5	147.0	156.0	155.0	154.5	158.0	158.0	151.5
3	-----	-----	-----	-----	132.0	141.5	151.0	151.5	146.0	147.0	149.5	146.0
4	-----	-----	-----	-----	127.5	138.5	148.5	148.0	142.0	142.5	141.5	139.0
5	-----	-----	-----	-----	125.0	135.0	144.0	142.5	140.0	144.0	146.0	139.0
6	-----	-----	-----	-----	(a)	132.0	140.0	140.0	139.0	134.0	141.5	132.5
7	-----	-----	-----	-----	-----	129.0	137.0	137.0	132.0	135.0	134.0	125.0
8	-----	-----	-----	-----	-----	126.0	132.0	131.0	128.0	134.5	137.5	123.0

[a]Not visible above tunnel background noise.

TABLE V. - Continued.

(g) M = 0.85, J = 4.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	145.0	153.0	155.5	154.0	149.5	147.5	146.0	143.0
2	-----	-----	-----	-----	(a)	143.5	145.0	149.0	149.0	142.5	135.0	(a)
3	-----	-----	-----	-----	-----	(a)	145.0	140.0	138.0	135.5	(a)	-----
4	-----	-----	-----	-----	-----	-----	135.0	141.5	139.0	134.0	-----	-----
5	-----	-----	-----	-----	-----	-----	(a)	136.5	136.5	131.5	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	133.5	133.0	129.5	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	(a)	133.0	(a)	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	130.0	-----	-----	-----

(h) M = 0.85, J = 4.0

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	131.5	137.5	145.0	153.0	157.0	155.5	150.0	147.0	145.5	141.0
2	-----	-----	(a)	(a)	(a)	143.5	141.5	148.5	149.0	142.0	141.0	(a)
3	-----	-----	-----	-----	-----	(a)	146.5	142.0	141.0	141.0	139.5	-----
4	-----	-----	-----	-----	-----	-----	135.0	142.0	138.0	132.5	(a)	-----
5	-----	-----	-----	-----	-----	-----	(a)	136.0	138.5	(a)	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	131.0	135.0	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	128.0	134.0	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	(a)	130.0	-----	-----	-----

(i) M = 0.85, J = 3.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	140.0	149.0	153.5	159.0	158.5	153.5	153.0	147.5	149.0
2	-----	-----	-----	(a)	136.0	145.5	143.5	151.0	153.0	150.0	145.5	141.0
3	-----	-----	-----	-----	(a)	(a)	148.5	145.5	141.0	144.0	137.5	136.5
4	-----	-----	-----	-----	-----	-----	139.0	141.5	141.0	133.5	131.0	134.5
5	-----	-----	-----	-----	-----	-----	(a)	135.0	140.0	133.0	134.0	(a)
6	-----	-----	-----	-----	-----	-----	-----	(a)	135.0	131.5	(a)	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	134.0	133.0	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	128.5	131.5	-----	-----

[a]Not visible above tunnel background noise.

TABLE V. - Continued.

(j) M = 0.85, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	137.0	141.0	150.5	152.5	160.0	160.5	157.5	157.5	154.0	149.5
2	-----	-----	(a)	(a)	138.0	137.0	142.0	148.5	154.0	152.0	150.0	134.5
3	-----	-----	-----	-----	(a)	136.5	148.5	148.0	136.5	145.0	141.5	136.0
4	-----	-----	-----	-----	-----	(a)	140.0	138.5	141.5	135.0	135.5	134.0
5	-----	-----	-----	-----	-----	-----	135.0	133.0	138.0	135.5	130.5	136.0
6	-----	-----	-----	-----	-----	-----	129.5	130.5	136.0	133.5	133.0	(a)
7	-----	-----	-----	-----	-----	-----	129.0	130.5	133.0	137.0	129.5	-----
8	-----	-----	-----	-----	-----	-----	127.0	128.0	128.5	135.5	132.0	-----

(k) M = 0.85, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	143.5	150.5	153.5	163.5	164.0	162.0	157.5	160.5	146.0
2	-----	-----	-----	(a)	139.5	151.0	139.0	150.5	156.0	156.0	153.0	143.0
3	-----	-----	-----	-----	(a)	139.5	144.0	150.0	134.0	149.0	149.0	140.0
4	-----	-----	-----	-----	-----	137.0	144.0	131.5	146.0	141.5	140.5	131.0
5	-----	-----	-----	-----	-----	(a)	138.0	136.5	137.0	142.0	138.0	(a)
6	-----	-----	-----	-----	-----	-----	133.5	133.0	138.0	140.5	138.5	-----
7	-----	-----	-----	-----	-----	-----	130.0	127.5	132.0	138.0	136.5	-----
8	-----	-----	-----	-----	-----	-----	128.5	126.5	131.0	135.0	131.0	-----

(l) M = 0.85, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	142.0	150.5	156.5	167.0	167.0	165.5	161.0	158.5	143.5
2	-----	-----	-----	(a)	140.0	150.0	151.5	150.5	157.0	157.5	156.0	141.0
3	-----	-----	-----	-----	134.0	146.0	150.5	153.5	147.5	146.0	149.5	143.5
4	-----	-----	-----	-----	128.5	139.0	148.0	146.5	149.0	146.0	141.5	139.0
5	-----	-----	-----	-----	(a)	135.0	142.0	141.0	139.0	144.5	145.0	135.0
6	-----	-----	-----	-----	-----	(a)	134.0	140.5	137.0	142.0	140.5	131.5
7	-----	-----	-----	-----	-----	-----	(a)	136.0	127.0	138.0	139.0	130.5
8	-----	-----	-----	-----	-----	-----	-----	128.0	130.0	138.0	134.5	126.5

[a]Not visible above tunnel background noise.

TABLE V. - Continued.

(m) M = 0.8, J = 4.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	137.0	143.5	147.0	151.5	150.0	146.5	142.0	144.0	142.5	138.5
2	-----	-----	(a)	(a)	136.5	147.5	147.5	144.0	144.0	138.5	136.0	(a)
3	-----	-----	-----	-----	(a)	140.5	139.5	138.5	135.5	131.5	(a)	-----
4	-----	-----	-----	-----	-----	135.5	135.5	134.0	(a)	(a)	-----	-----
5	-----	-----	-----	-----	-----	(a)	134.0	129.0	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	133.0	129.0	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	129.0	127.0	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	127.0	123.0	-----	-----	-----	-----

(n) M = 0.8, J = 4.0

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	138.5	141.5	145.5	154.5	153.0	150.0	146.5	147.0	145.0	140.0
2	-----	-----	(a)	(a)	136.5	147.5	148.0	146.0	143.0	143.0	141.0	134.0
3	-----	-----	-----	-----	(a)	143.0	142.5	141.5	139.5	(a)	(a)	(a)
4	-----	-----	-----	-----	-----	137.0	139.0	133.5	(a)	-----	-----	-----
5	-----	-----	-----	-----	-----	133.0	136.5	132.0	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	128.0	135.0	133.0	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	(a)	130.0	129.0	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	(a)	127.0	-----	-----	-----	-----

(o) M = 0.8, J = 3.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	134.0	135.0	135.0	140.5	144.5	156.5	157.0	155.0	151.0	148.5	146.0	140.0
2	(a)	(a)	(a)	(a)	137.5	149.5	151.0	150.0	150.5	138.0	141.0	140.5
3	-----	-----	-----	-----	(a)	144.0	141.0	142.5	142.0	(a)	(a)	(a)
4	-----	-----	-----	-----	-----	139.5	141.5	134.0	132.5	-----	-----	-----
5	-----	-----	-----	-----	-----	136.0	140.0	137.0	129.0	-----	-----	-----
6	-----	-----	-----	-----	-----	(a)	134.5	134.5	130.0	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	131.5	131.0	127.0	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	129.0	128.0	126.0	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE V. - Continued.

(p) M = 0.8, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	141.5	140.5	137.5	145.5	148.5	156.5	159.0	158.0	155.0	153.0	155.0	143.0
2	(a)	(a)	(a)	(a)	135.0	151.0	153.5	154.5	152.5	151.5	147.0	141.0
3	-----	-----	-----	-----	(a)	144.0	141.0	141.5	145.5	144.5	135.0	136.0
4	-----	-----	-----	-----	-----	138.5	144.0	138.0	134.5	130.5	133.5	134.5
5	-----	-----	-----	-----	-----	134.0	139.0	141.0	129.0	131.5	(a)	(a)
6	-----	-----	-----	-----	-----	(a)	136.0	132.0	134.5	128.0	-----	-----
7	-----	-----	-----	-----	-----	-----	133.5	133.0	130.0	126.5	-----	-----
8	-----	-----	-----	-----	-----	-----	128.5	128.0	127.0	(a)	-----	-----

(q) M = 0.8, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	141.5	141.0	140.5	145.5	148.5	160.0	163.5	162.5	159.0	152.5	155.0	151.5
2	(a)	(a)	(a)	134.5	143.0	152.5	153.0	154.5	154.5	151.0	148.0	144.5
3	-----	-----	-----	(a)	(a)	147.5	145.5	140.0	147.5	142.5	145.0	137.0
4	-----	-----	-----	-----	-----	142.5	145.5	143.5	136.5	138.5	140.5	132.0
5	-----	-----	-----	-----	-----	137.0	141.0	137.0	138.0	137.5	134.0	133.0
6	-----	-----	-----	-----	-----	133.5	139.5	134.0	137.0	135.0	133.0	128.5
7	-----	-----	-----	-----	-----	(a)	136.5	133.0	134.5	132.5	130.0	127.0
8	-----	-----	-----	-----	-----	-----	134.0	128.0	133.0	129.0	132.0	133.0

(r) M = 0.8, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	140.0	139.0	138.0	145.5	149.5	162.5	166.0	165.0	164.0	161.0	158.0	156.5
2	(a)	(a)	(a)	135.5	145.5	150.5	156.5	157.0	157.5	154.0	151.0	141.5
3	-----	-----	-----	(a)	137.0	148.0	150.0	147.5	148.5	147.0	143.5	140.0
4	-----	-----	-----	-----	129.5	145.0	146.5	147.5	145.5	141.5	139.5	138.5
5	-----	-----	-----	-----	(a)	138.0	138.5	139.0	142.5	140.0	136.0	133.0
6	-----	-----	-----	-----	-----	133.0	136.0	137.0	138.0	136.5	135.0	131.0
7	-----	-----	-----	-----	-----	(a)	135.0	132.0	137.0	134.0	131.5	128.0
8	-----	-----	-----	-----	-----	-----	(a)	(a)	136.0	133.5	132.0	128.0

[a]Not visible above tunnel background noise.

TABLE V. - Continued.

(s) M = 0.75, J = 4.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(t) M = 0.75, J = 4.0

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	145.5	151.5	150.0	146.5	135.5	(a)	(a)	(a)
2	-----	-----	-----	-----	137.5	143.0	143.0	139.0	138.0	-----	-----	-----
3	-----	-----	-----	-----	(a)	141.0	139.5	136.5	(a)	-----	-----	-----
4	-----	-----	-----	-----	-----	137.5	134.5	133.0	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	132.0	130.5	(a)	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	130.0	129.0	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	128.0	127.0	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	(a)	(a)	-----	-----	-----	-----	-----

(u) M = 0.75, J = 3.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	137.5	137.5	145.5	151.0	154.5	152.0	151.5	151.0	146.5	143.5	143.0
2	-----	(a)	(a)	135.0	141.0	147.0	147.5	146.0	139.0	138.5	133.5	137.5
3	-----	-----	-----	(a)	138.5	144.0	141.0	138.0	(a)	(a)	(a)	(a)
4	-----	-----	-----	-----	132.5	137.5	137.5	135.5	-----	-----	-----	-----
5	-----	-----	-----	-----	(a)	136.0	132.0	(a)	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	132.5	128.0	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	130.0	129.0	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	127.0	126.0	-----	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE V. - Continued.

(v) M = 0.75, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	141.5	138.5	138.5	144.5	149.5	156.5	156.0	154.0	152.5	148.5	143.5	140.5
2	(a)	(a)	132.5	135.5	143.5	152.0	152.5	150.0	146.5	140.5	137.0	136.5
3	-----	-----	(a)	(a)	138.5	146.5	146.5	145.0	139.5	135.0	136.0	137.0
4	-----	-----	-----	-----	135.5	143.5	139.5	135.5	134.0	132.5	132.0	132.5
5	-----	-----	-----	-----	(a)	138.0	134.0	131.5	131.0	130.5	(a)	(a)
6	-----	-----	-----	-----	-----	136.0	134.0	128.0	(a)	128.5	-----	-----
7	-----	-----	-----	-----	-----	133.0	132.0	126.5	127.0	(a)	-----	-----
8	-----	-----	-----	-----	-----	129.0	129.0	(a)	(a)	(a)	-----	-----

(w) M = 0.75, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	146.0	144.0	146.0	143.0	150.0	160.0	160.5	159.5	159.5	154.5	149.5	145.5
2	(a)	(a)	(a)	138.5	144.0	155.5	157.0	156.0	151.0	146.0	149.0	144.5
3	-----	-----	-----	(a)	138.5	150.0	146.5	147.0	146.0	137.0	142.0	136.5
4	-----	-----	-----	-----	133.5	146.5	144.5	140.5	134.5	133.5	134.0	137.0
5	-----	-----	-----	-----	129.0	142.5	140.0	141.0	138.0	134.0	132.0	130.5
6	-----	-----	-----	-----	(a)	139.5	138.0	134.5	132.0	129.0	130.0	130.5
7	-----	-----	-----	-----	-----	136.0	137.0	133.0	132.0	126.0	129.0	129.0
8	-----	-----	-----	-----	-----	133.0	132.0	128.5	(a)	(a)	(a)	128.0

(x) M = 0.75, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	141.5	142.5	142.5	143.0	145.5	161.5	163.0	162.0	158.0	160.5	160.5	146.5
2	(a)	138.5	138.0	140.0	148.0	155.0	155.5	155.5	155.0	153.5	145.5	142.5
3	-----	(a)	(a)	(a)	137.0	150.0	144.5	146.0	147.0	139.0	141.0	140.5
4	-----	-----	-----	-----	135.0	145.0	144.0	139.5	138.5	141.0	134.0	137.0
5	-----	-----	-----	-----	(a)	141.0	139.0	141.0	141.0	137.0	134.5	133.0
6	-----	-----	-----	-----	-----	138.5	137.5	133.0	137.0	132.0	135.0	130.5
7	-----	-----	-----	-----	-----	136.0	135.0	133.5	132.5	129.0	128.0	127.0
8	-----	-----	-----	-----	-----	131.5	133.0	129.0	131.5	128.0	127.5	125.0

[a]Not visible above tunnel background noise.

TABLE V. - Continued.

(y) M = 0.7, J = 4.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(z) M = 0.7, J = 4.0

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	141.0	143.5	143.0	142.5	141.0	137.5	(a)	(a)
2	-----	-----	-----	-----	(a)	(a)	(a)	(a)	(a)	-----	-----	-----
3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(aa) M = 0.7, J = 3.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	141.0	143.0	147.0	145.0	142.0	139.0	140.0	(a)	(a)
2	-----	-----	-----	132.0	135.0	139.5	137.0	136.5	135.5	(a)	-----	-----
3	-----	-----	-----	(a)	(a)	132.0	(a)	(a)	(a)	-----	-----	-----
4	-----	-----	-----	-----	-----	(a)	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE V. - Continued.

(bb) M = 0.7, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref $2x10^{-5}$ N/m^2											
1 (BPF)	(a)	(a)	(a)	144.5	150.5	154.0	149.0	142.5	142.0	146.0	144.5	(a)
2	-----	-----	-----	138.0	139.5	148.0	145.5	142.0	138.0	135.5	131.0	-----
3	-----	-----	-----	(a)	137.5	143.0	140.5	138.0	(a)	(a)	(a)	-----
4	-----	-----	-----	-----	135.5	139.5	137.0	132.0	-----	-----	-----	-----
5	-----	-----	-----	-----	132.0	137.0	132.0	128.5	-----	-----	-----	-----
6	-----	-----	-----	-----	128.0	135.0	129.0	(a)	-----	-----	-----	-----
7	-----	-----	-----	-----	125.0	132.0	126.0	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	(a)	129.5	125.0	-----	-----	-----	-----	-----

(cc) M = 0.7, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref $2x10^{-5}$ N/m^2											
1 (BPF)	144.0	144.5	143.5	151.5	154.5	158.0	157.5	157.0	156.0	152.5	149.0	146.5
2	(a)	(a)	(a)	140.0	148.0	151.0	152.0	150.5	144.0	144.0	140.0	139.0
3	-----	-----	-----	137.5	140.0	148.0	145.0	144.0	140.0	139.0	139.5	135.0
4	-----	-----	-----	129.5	138.5	142.0	140.0	135.5	129.5	134.5	132.5	131.5
5	-----	-----	-----	(a)	133.0	139.5	136.5	134.0	128.0	132.5	132.0	130.5
6	-----	-----	-----	-----	131.0	136.5	132.5	127.0	124.0	(a)	(a)	(a)
7	-----	-----	-----	-----	127.0	134.0	131.5	125.0	126.0	-----	-----	-----
8	-----	-----	-----	-----	(a)	132.0	129.0	123.0	124.0	-----	-----	-----

(dd) M = 0.7, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref $2x10^{-5}$ N/m^2											
1 (BPF)	149.0	151.0	149.5	154.0	152.5	157.0	158.5	158.5	158.5	155.0	150.5	148.0
2	139.5	139.5	138.5	140.5	145.5	155.5	156.0	154.0	151.5	143.0	141.5	138.0
3	(a)	135.5	135.0	137.0	144.5	146.5	146.0	145.5	142.5	138.0	135.5	133.0
4	-----	(a)	131.0	131.5	137.5	144.0	142.5	140.0	133.0	137.0	135.0	132.5
5	-----	-----	(a)	129.0	135.0	140.0	141.5	136.5	129.0	132.0	129.5	128.0
6	-----	-----	-----	(a)	131.5	139.0	140.0	135.5	129.5	127.0	129.0	132.0
7	-----	-----	-----	-----	(a)	137.0	135.0	133.0	127.0	125.0	126.5	126.0
8	-----	-----	-----	-----	-----	134.0	134.5	128.0	(a)	(a)	(a)	125.5

[a]Not visible above tunnel background noise.

TABLE V. - Continued.

(ee) M = 0.65, J = 4.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
2	------	------	------	------	------	------	------	------	------	------	------	------
3	------	------	------	------	------	------	------	------	------	------	------	------
4	------	------	------	------	------	------	------	------	------	------	------	------
5	------	------	------	------	------	------	------	------	------	------	------	------
6	------	------	------	------	------	------	------	------	------	------	------	------
7	------	------	------	------	------	------	------	------	------	------	------	------
8	------	------	------	------	------	------	------	------	------	------	------	------

(ff) M = 0.65, J = 4.0

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
2	------	------	------	------	------	------	------	------	------	------	------	------
3	------	------	------	------	------	------	------	------	------	------	------	------
4	------	------	------	------	------	------	------	------	------	------	------	------
5	------	------	------	------	------	------	------	------	------	------	------	------
6	------	------	------	------	------	------	------	------	------	------	------	------
7	------	------	------	------	------	------	------	------	------	------	------	------
8	------	------	------	------	------	------	------	------	------	------	------	------

(gg) M = 0.65, J = 3.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	134.0	139.5	142.5	140.0	138.0	134.0	(a)	(a)	(a)
2	------	------	------	(a)	(a)	(a)	(a)	(a)	(a)	------	------	------
3	------	------	------	------	------	------	------	------	------	------	------	------
4	------	------	------	------	------	------	------	------	------	------	------	------
5	------	------	------	------	------	------	------	------	------	------	------	------
6	------	------	------	------	------	------	------	------	------	------	------	------
7	------	------	------	------	------	------	------	------	------	------	------	------
8	------	------	------	------	------	------	------	------	------	------	------	------

[a]Not visible above tunnel background noise.

TABLE V. - Continued.

(hh) M = 0.65, J = 3.5

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	139.0	142.5	146.5	146.0	144.5	142.5	138.5	136.5	(a)
2	-----	-----	-----	131.0	132.5	135.0	132.0	128.0	(a)	(a)	(a)	-----
3	-----	-----	-----	(a)	(a)	(a)	(a)	(a)	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(ii) M = 0.65, J = 3.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	141.0	147.0	151.0	149.5	148.0	141.5	137.5	(a)	(a)
2	-----	-----	-----	(a)	137.5	143.5	142.0	140.0	134.5	(a)	-----	-----
3	-----	-----	-----	-----	133.0	135.5	131.0	(a)	(a)	-----	-----	-----
4	-----	-----	-----	-----	128.0	131.5	(a)	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	(a)	128.0	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	(a)	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(jj) M = 0.65, J = 3.06

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	139.0	139.5	136.0	148.0	154.0	157.5	155.5	151.5	140.5	147.0	148.0	143.5
2	(a)	139.5	138.0	137.0	142.0	146.5	146.5	145.0	144.5	142.0	138.5	134.5
3	-----	(a)	132.5	131.5	135.5	139.0	134.5	132.5	131.5	131.5	134.5	132.0
4	-----	-----	(a)	129.5	134.5	135.5	135.0	131.0	128.5	128.0	128.5	129.5
5	-----	-----	-----	(a)	130.0	134.5	127.5	(a)	(a)	(a)	(a)	(a)
6	-----	-----	-----	-----	126.5	132.0	125.5	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	123.0	127.0	(a)	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	(a)	124.0	-----	-----	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

TABLE V. - Continued.

(kk) M = 0.60, J = 4.25

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
2	----	----	----	----	----	----	----	----	----	----	----	----
3	----	----	----	----	----	----	----	----	----	----	----	----
4	----	----	----	----	----	----	----	----	----	----	----	----
5	----	----	----	----	----	----	----	----	----	----	----	----
6	----	----	----	----	----	----	----	----	----	----	----	----
7	----	----	----	----	----	----	----	----	----	----	----	----
8	----	----	----	----	----	----	----	----	----	----	----	----

(ll) M = 0.6, J = 4.0

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
2	----	----	----	----	----	----	----	----	----	----	----	----
3	----	----	----	----	----	----	----	----	----	----	----	----
4	----	----	----	----	----	----	----	----	----	----	----	----
5	----	----	----	----	----	----	----	----	----	----	----	----
6	----	----	----	----	----	----	----	----	----	----	----	----
7	----	----	----	----	----	----	----	----	----	----	----	----
8	----	----	----	----	----	----	----	----	----	----	----	----

(mm) M = 0.60, J = 3.75

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
2	----	----	----	----	----	----	----	----	----	----	----	----
3	----	----	----	----	----	----	----	----	----	----	----	----
4	----	----	----	----	----	----	----	----	----	----	----	----
5	----	----	----	----	----	----	----	----	----	----	----	----
6	----	----	----	----	----	----	----	----	----	----	----	----
7	----	----	----	----	----	----	----	----	----	----	----	----
8	----	----	----	----	----	----	----	----	----	----	----	----

[a]Not visible above tunnel background noise.

TABLE V. - Continued.

(nn) $M = 0.60$, $J = 3.5$

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(oo) $M = 0.6$, $J = 3.25$

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	(a)	136.5	142.0	146.0	145.0	143.5	140.5	135.5	(a)	(a)
2	-----	-----	-----	(a)	(a)	128.0	129.5	127.5	(a)	(a)	-----	-----
3	-----	-----	-----	-----	-----	(a)	(a)	(a)	-----	-----	-----	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(pp) $M = 0.6$, $J = 3.06$

Harmonic number	Transducer											
	1	2	3	4	5	6	7	8	9	10	11	12
	Sound pressure level of harmonic, SPL, dB, ref 2×10^{-5} N/m^2											
1 (BPF)	(a)	(a)	137.0	142.0	147.0	150.5	150.5	149.0	146.5	142.5	140.5	142.0
2	-----	-----	(a)	(a)	(a)	132.5	133.0	130.0	123.5	126.5	130.0	(a)
3	-----	-----	-----	-----	-----	(a)	(a)	(a)	(a)	(a)	(a)	-----
4	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

[a]Not visible above tunnel background noise.

ORIGINAL PAGE IS
OF POOR QUALITY

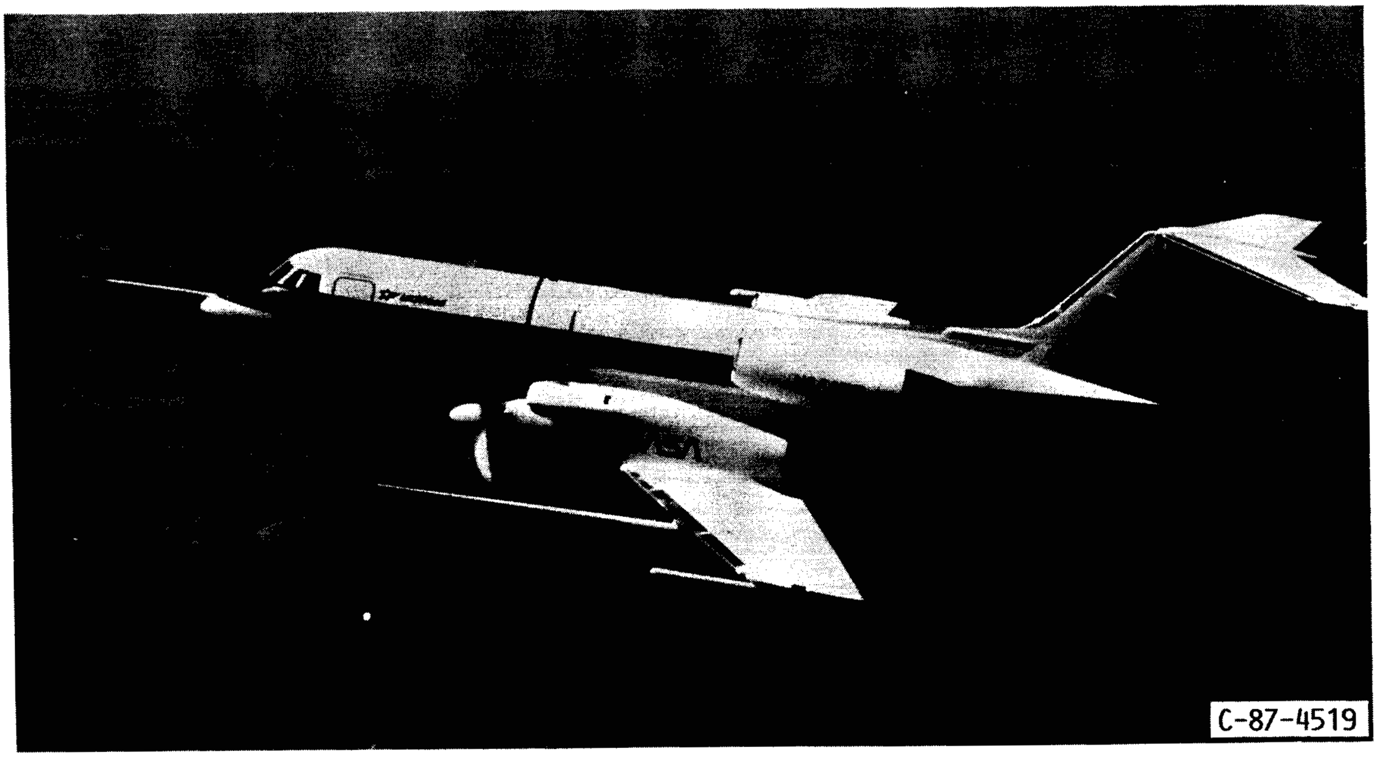
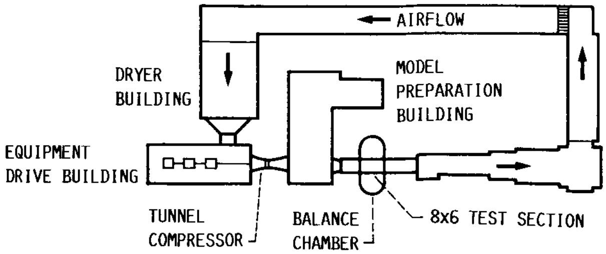


FIGURE 1. - LARGE-SCALE ADVANCED PROPFAN ON TEST BED AIRCRAFT.



(A) PLAN VIEW OF NASA LEWIS 8- BY 6-FOOT WIND TUNNEL.

(B) SR-7A IN TEST SECTION.

FIGURE 2. - WIND TUNNEL AND PROPELLER INSTALLATION.

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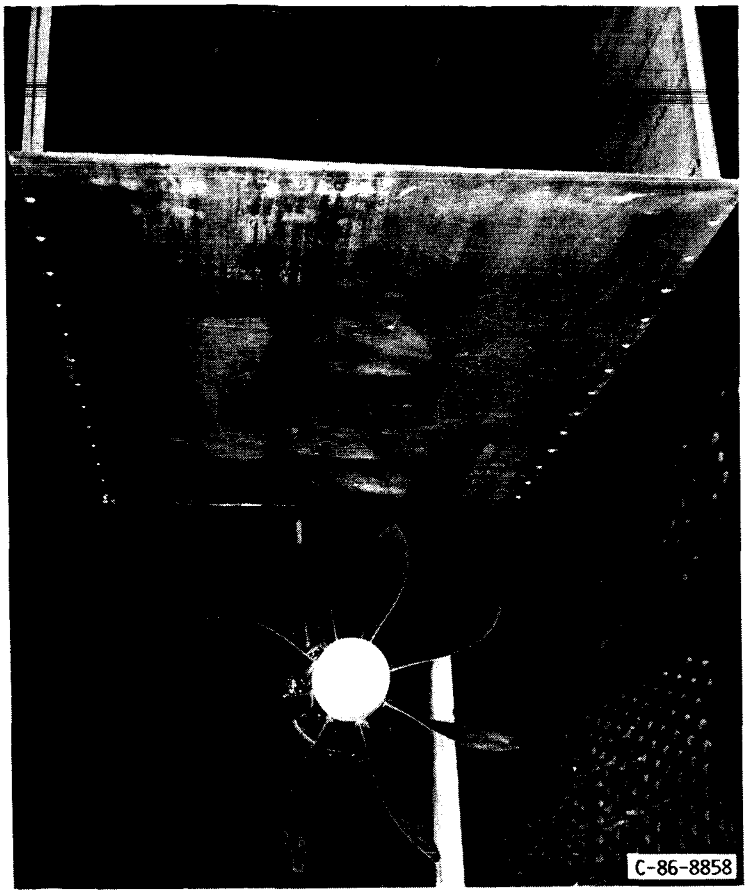
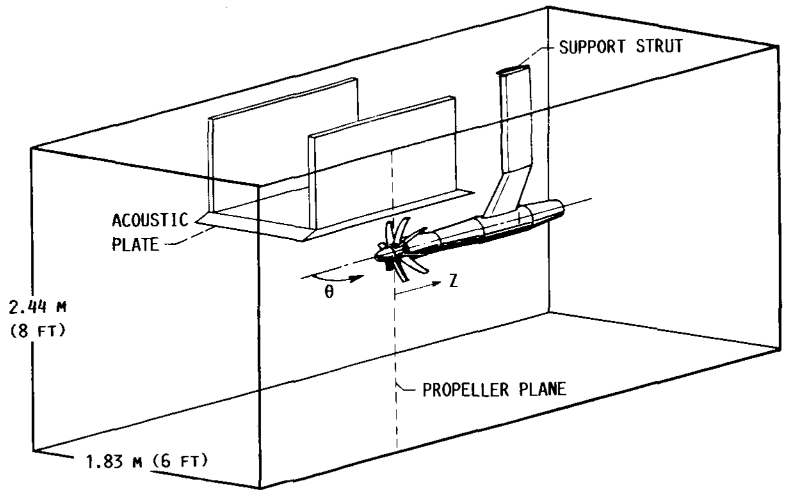


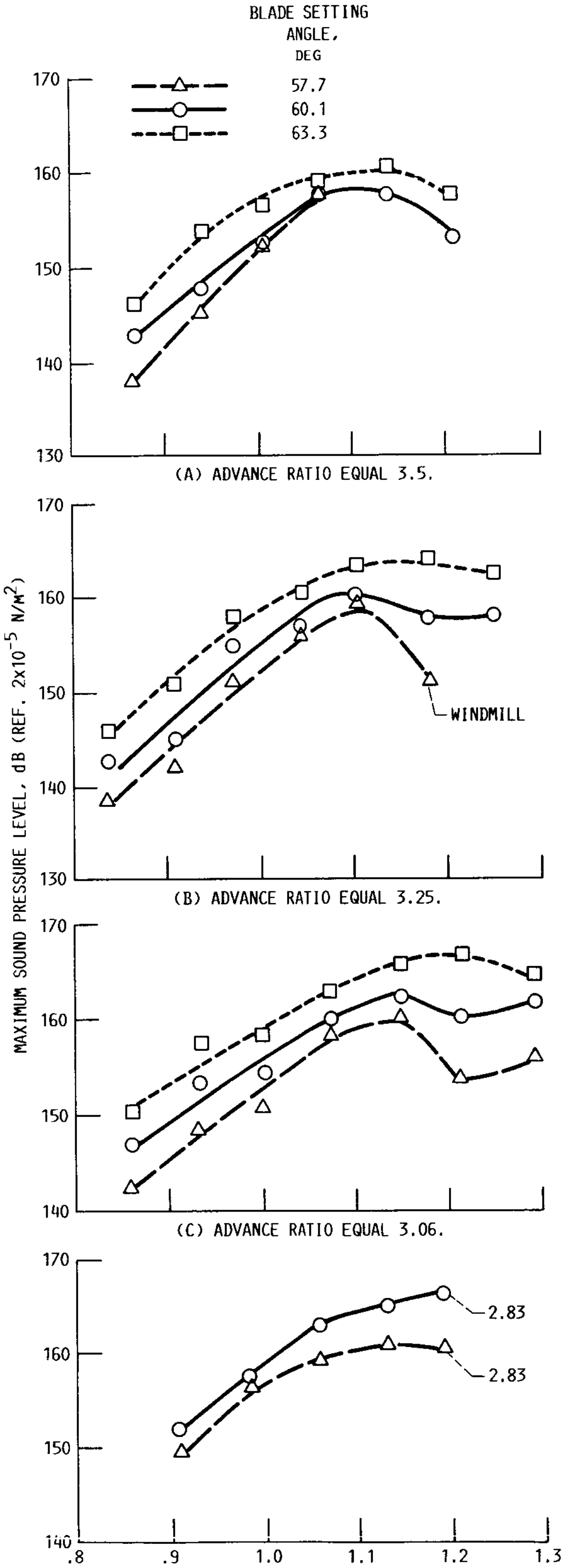
(A) PHOTOGRAPH.



POSITION	TRANSDUCER (PLATE 0.3 DIAMETER FROM TIP)											
	1	2	3	4	5	6	7	8	9	10	11	12
	TRANSDUCER POSITION, CM (IN.)											
Z	-46.7 (-18.4)	-41.7 (-16.4)	-30.5 (-12.0)	-16.0 (-6.3)	-8.9 (-3.5)	0.8 (0.3)	8.9 (3.5)	12.4 (4.9)	18.0 (7.1)	25.0 (9.9)	28.7 (11.3)	42.4 (16.7)
	ANGLE FROM UPSTREAM, DEG											
θ	46.8	50.0	58.5	72.2	80	90.9	100	104	110	116.8	120	130.4

(B) TRANSDUCER LOCATIONS.

FIGURE 3. - ACOUSTIC PLATE.



(A) ADVANCE RATIO EQUAL 3.5.

(B) ADVANCE RATIO EQUAL 3.25.

(C) ADVANCE RATIO EQUAL 3.06.

(D) ADVANCE RATIO EQUAL 2.75 EXCEPT WHERE NOTED.

FIGURE 4. - MAXIMUM BLADE PASSING TONE VARIATION WITH HELICAL TIP MACH NUMBER AT CONSTANT ADVANCE RATIO.

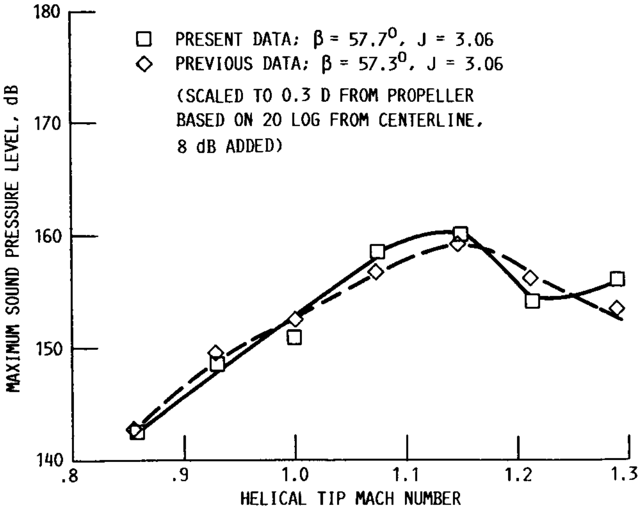
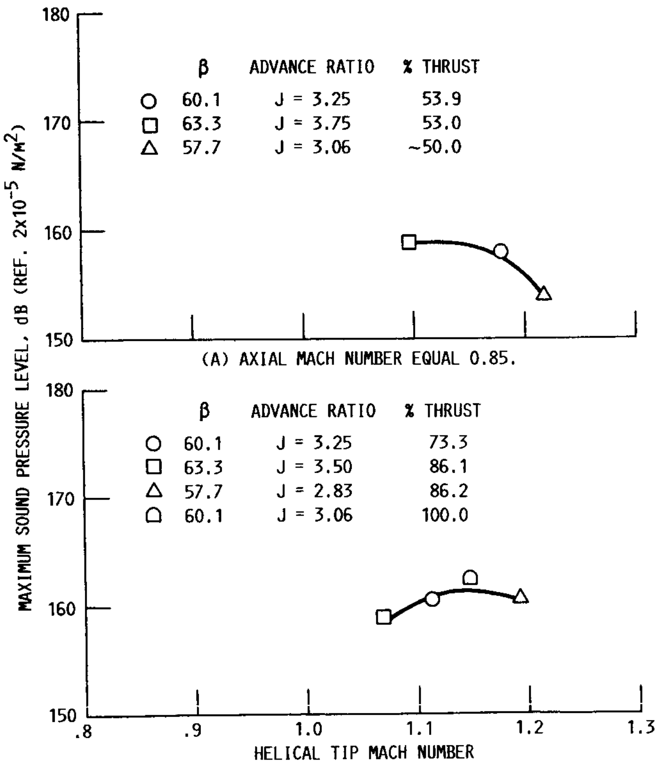


FIGURE 5. - COMPARISON OF MAXIMUM BLADE PASSING TONE VARIATION FROM PREVIOUS DATA WITH PRESENT DATA.



(A) AXIAL MACH NUMBER EQUAL 0.85.

(B) AXIAL MACH NUMBER EQUAL 0.80.

FIGURE 6. - MAXIMUM BLADE PASSING TONE VARIATION WITH HELICAL TIP MACH NUMBER AT APPROXIMATELY CONSTANT THRUST.

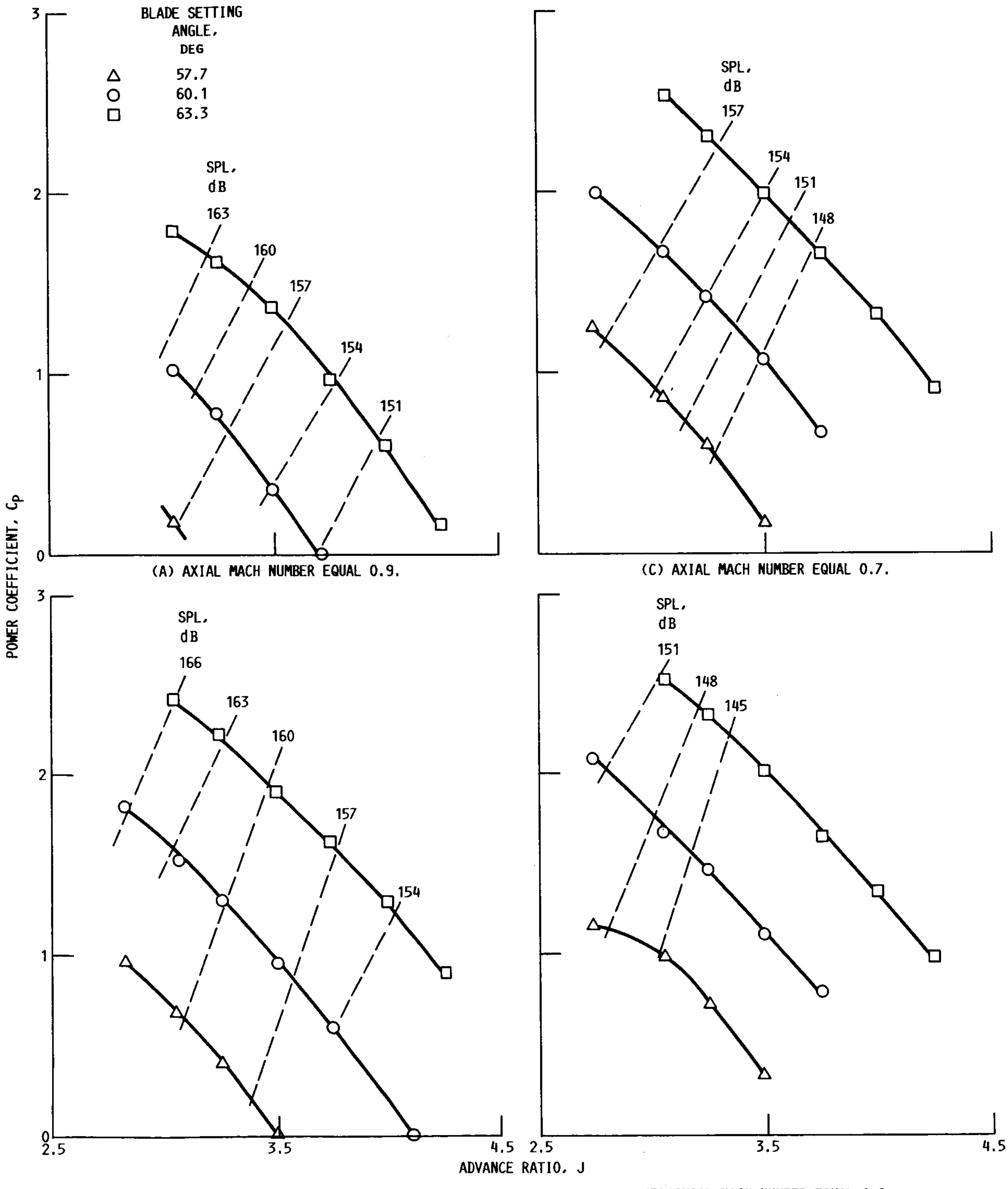


FIGURE 7. - MAXIMUM BLADE PASSING TONE LEVELS ON PROPELLER OPERATING MAP.

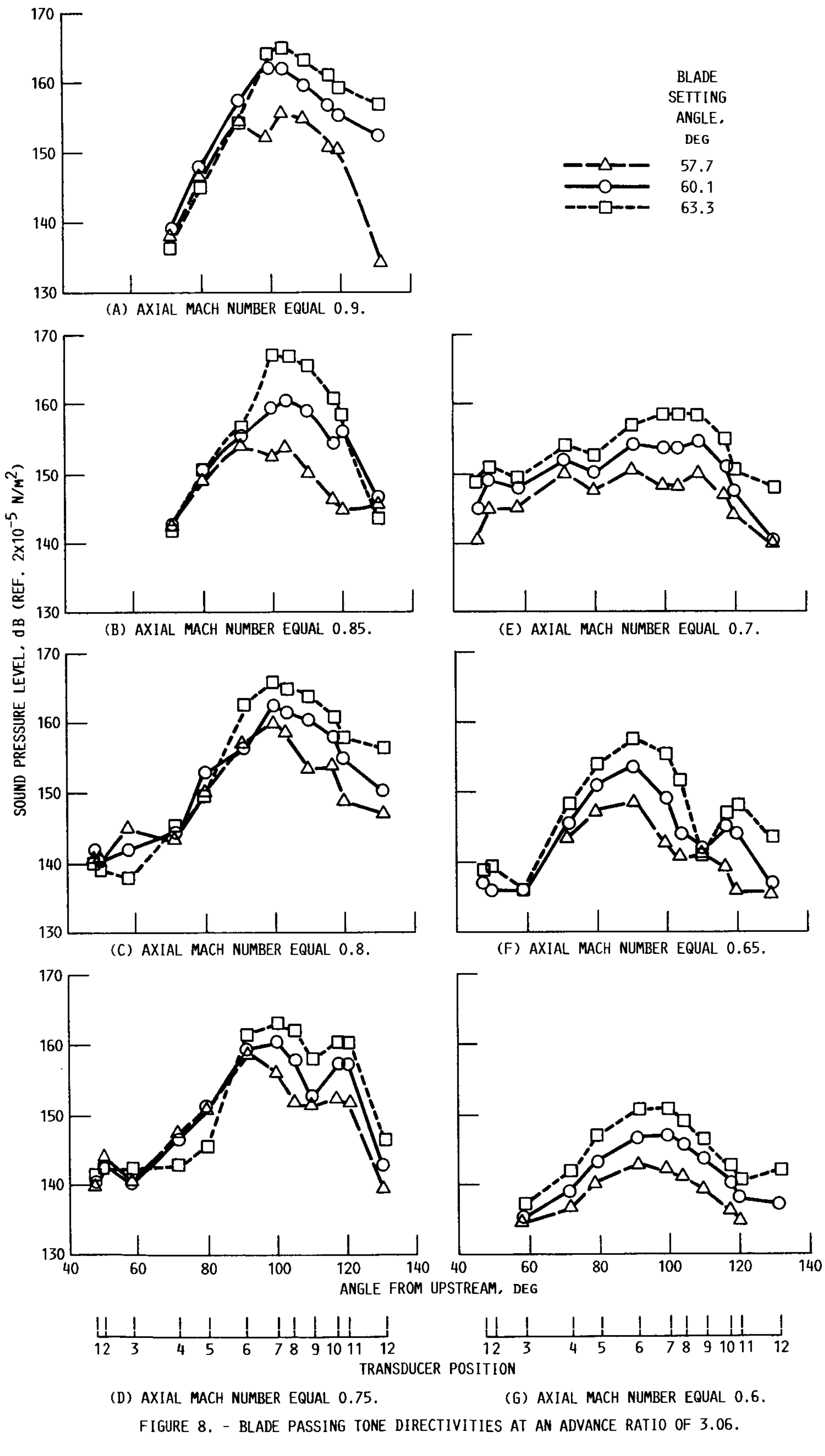


FIGURE 8. - BLADE PASSING TONE DIRECTIVITIES AT AN ADVANCE RATIO OF 3.06.

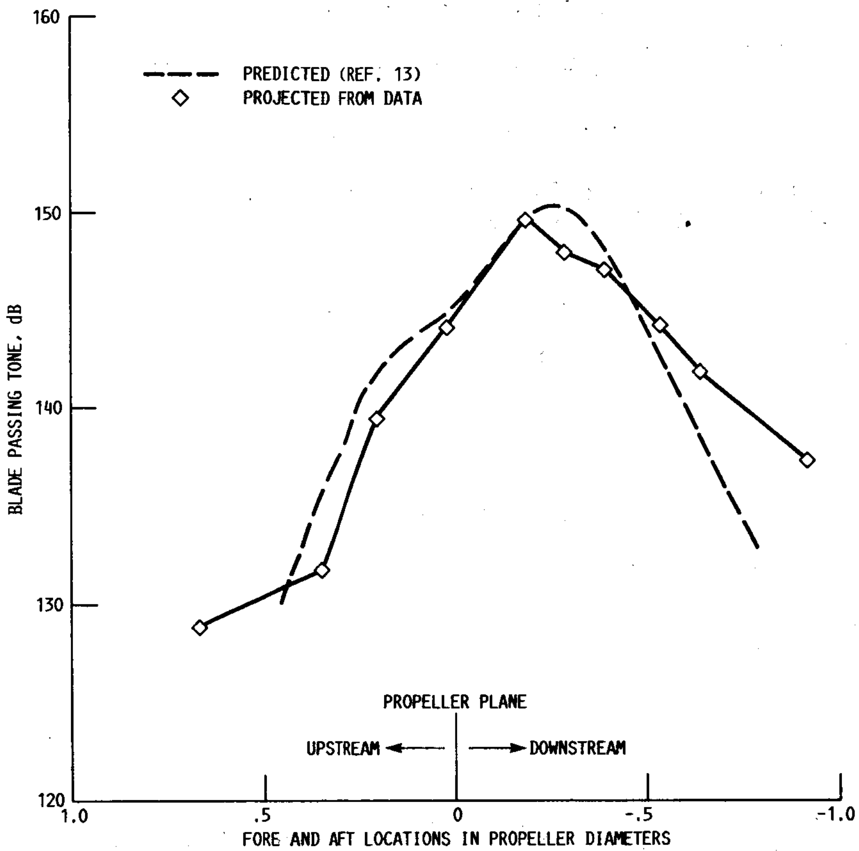


FIGURE 9. - BLADE PASSING TONE ON AIRPLANE FUSELAGE.

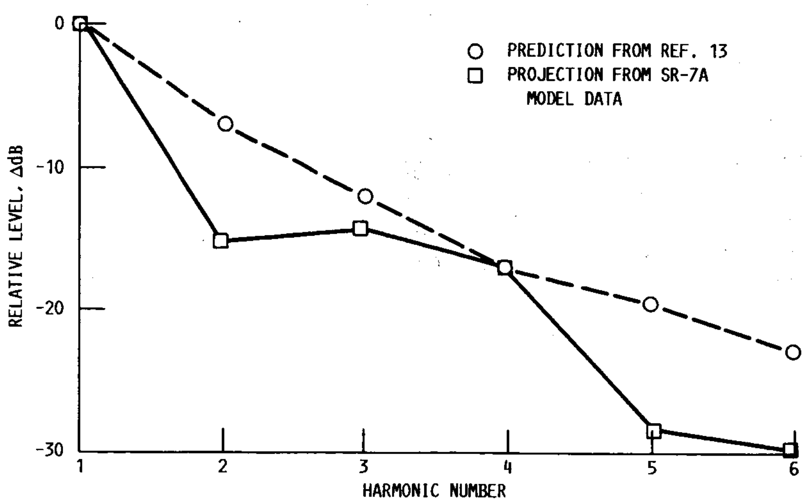


FIGURE 10. - LEVEL OF BLADE PASSAGE FREQUENCY HARMONICS RELATIVE TO FUNDAMENTAL AT MAXIMUM NOISE LOCATION FOR CRUISE CONDITION OF FULL-SCALE PROPELLER.

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15. Supplementary Notes

A shortened version of this report will be presented at the 11th AIAA Aero-acoustics Conference, Sunnyvale, California, October 19-21, 1987. James H. Dittmar, NASA Lewis Research Center; David B. Stang, Sverdrup Technology, Inc., Lewis Research Center, Cleveland, Ohio 44135.

16. Abstract

Noise data on the Large-scale Advanced Propfan (LAP) propeller model SR-7A were taken in the NASA Lewis Research Center 8- by 6- Foot Wind Tunnel. The maximum blade passing tone noise first rises with increasing helical tip Mach number to a peak level, then remains the same or decreases from its peak level when going to higher helical tip Mach numbers. This trend was observed for operation at both constant advance ratio and approximately equal thrust. This noise reduction or, leveling out at high helical tip Mach numbers, points to the use of higher propeller tip speeds as a possible method to limit airplane cabin noise while maintaining high flight speed and efficiency. Projections of the tunnel model data are made to the full scale LAP propeller mounted on the test bed aircraft and compared with predictions. The prediction method is found to be somewhat conservative in that it slightly overpredicts the projected model data at the peak.

17. Key Words (Suggested by Author(s)) Propeller noise; Noise; Supersonic tip speed	18. Distribution Statement Unclassified - Unlimited; Subject Category 71

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